N. A. Harvey.

ELEMENTARY PSYCHOLOGY

A TEXT-BOOK FOR NORMAL SCHOOLS
AND FOR
TEACHERS' PROFESSIONAL READING COURSES

BY
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PREFACE

The present volume has grown up in the class room out of an attempt to discover what it is profitable to know and what it is possible to teach in psychology to a class of prospective teachers. The results observed in teaching these lessons to more than a thousand students seem to justify both the selection of material and the adoption of the method.

The fundamental principle upon which this book is based is that psychology is a natural science, having affiliations rather with biology than with philosophical disciplines. The subject-matter is the student's own experiences, and the problem of the science is to enable him to understand and to interpret them, and to see their relations to each other. Such knowledge of his own mental processes is necessary to enable a teacher to understand the nature of the children that he is called upon to teach, as well as to discover the pedagogical content of the subjects of instruction.

The book is properly described as an elementary psychology, and presupposes no previous knowledge of psychological conceptions, while treating all phases of the general subject. It is intended that every statement shall be understood, and the manner of statement is intended to leave no doubt as to what is meant. Attention is invited to the following points:

First. The emphasis that is laid upon physiological processes. This emphasis is relied upon, not only as a method of making obscure topics plain, but it is believed to be an essential element in psychology proper. Mental

and physiological are two aspects of a single process, and neither can be understood without the other. This feature of the book will present an especial appeal to teachers of science.

Second. The development of the idea of a psychon, composed of the concomitants of the elements of a nervous current.

Third. The manner in which the mental processes are consistently related to each other by means of their physiological concomitants.

Fourth. Brief discussions of individual experiences of interest to every person. Such are sleep, dreams, hallucinations, illusions, number forms, colored hearing, imaginary playmates, hypnotism, visual projection, etc.

Fifth. The mental development of the child, and the explanation of the transformations that a child undergoes through the periods of infancy, childhood and adolescence, as determined by the development of instincts at different times.

Sixth. The quotations from many psychologists at the end of the chapters. These are intended to serve as references to the same subjects, as well as to present statements corroborating the positions advanced in the chapters, or to present contradictory opinions.

Seventh. Brief definitions at the ends of the chapters, where they will be most serviceable.

It is believed that these several features will commend the book to many teachers who are sincerely puzzled about what to teach and how to teach it in psychology.

NATHAN A. HARVEY.

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CHAPTER I

The Brain

Why Study the Brain?—We begin our study of psychology with an examination of the brain, because it is believed that the brain and nervous system is more intimately connected with mental processes than is any other part of the body. It has not always been believed that such is the case. Aristotle could think of no function for the brain except to lubricate the eyelids.

The Heart as the Location of Mental Functions.—When we send heart-shaped valentines on the fourteenth of February, we are suggesting a system of psychology which indicates that some of the mental processes, such as the affections, are located in the heart. When we talk about a man's being faint-hearted, or chicken-hearted, or big-hearted, we imply the same thing. The words courage and courageous contain the French word for heart, and imply that the heart is the seat of this feeling. Likewise, when we speak of the opposition between the head and the heart, we indicate that the intellectual processes are located in the head, but the feelings are located in the heart.

The Blood.—When two men are angry, we sometimes hear that there is bad blood between them. Some persons are said to be blue-blooded, or hot-blooded, or cold-blooded, which seems to imply that certain of the mental characteristics are associated with the blood.

The Liver.—Melancholy, choleric, and choler imply that some of the mental processes are dependent upon

the liver. So we understand when jealousy is personified as the green-eyed monster, that the excessive secretion of bile, which is a symptom of the disease called jaundice, and which promptly shows itself in the greenish coloring of the whites of the eyes, is likewise associated with certain of the feelings. Occasionally we read in literature of one's "venting his spleen," which indicates that the organ named is the seat of some of the mental processes.

The Breath and the Lungs.—But the words spirit and inspiration imply that the lungs, or the breath constitutes the real location of the soul, or the essential part of man. The word spirit means breath, so when we say that the spirit has left the body we mean to assert that the breath and the lungs constituted the location of all that made mental action possible.

The First Line of Evidence.—However, we now believe that no other part of the body is so closely connected with any mental process as is the brain and nervous system. There are four distinct lines of evidence that lead us to that conclusion. First, the brain of man is larger than the brain of any other animal. The thinking capacity of man is greater than the thinking capacity of any other animal. Consequently we are inclined to believe that there must be some kind of relation between the large brain and the large thinking capacity.

Conclusion Probable Only.—From the way in which our conclusion is drawn, it will be impossible to assert that the large brain is the cause of the large thinking capacity, or that the large thinking capacity is the cause of the large brain. All that we can assert is that there is probably some connection between the large brain and the large thinking capacity.

Brain of the Elephant and of the Whale.—Man has a larger brain than any other animal except the elephant

and the whale. Why, then, do not the elephant and the whale surpass man in their ability to think? The great size of the body of the elephant and of the whale makes a great demand upon the nervous energy of these animals in order to move the muscles. So, while the large brain generates a vast amount of nervous energy, so much is employed in moving the muscles that there is not a large surplus to be employed in thinking. In this way we may account for the large brain of the elephant and of the whale and their relatively smaller amount of intelligence.

Size of the Brain.—We may consider two pounds as about the minimum weight of the human brain, and four pounds as the maximum, although a very few brains have been weighed of more than four pounds, and in one or more cases, as much as five pounds. If the brain grows to be no larger than two pounds, the person either dies or is a microcephalic idiot. More than ninety-nine persons in a hundred have brain weights between two and a half, and three and a half pounds. For men, the average brain weight is about three pounds and two ounces; while for women, it is about two pounds and thirteen ounces. The weight of the elephant's brain is from six to eight pounds, while the largest whales may have a brain weight of even more. However, no other animal than the elephant and the whale has even approximately so large a brain weight as does man, notwithstanding the body weight may be much greater.

Second Line of Evidence.—The second reason is very nearly like the first. The relative proportion of brain weight to weight of body is greater in man than in any other animal (with very few exceptions). The thinking capacity of man is greater than that of any other animal. Hence we are inclined to believe that the great thinking

capacity is in some way associated with the great relative proportion of brain weight.

Proportion of Brain Weight.—In man, the brain constitutes about one-fiftieth of the weight of the body. A person who weighs two hundred pounds ought, then, to have a brain weight of about four pounds, while the person who weighs one hundred pounds ought to have a brain weight of two pounds. The fact is that the very heavy men, two hundred pounds or more, are not likely to have a brain weight of four pounds. Consequently their proportion of brain weight to weight of body is less than one-fiftieth. A small person is likely to have a much greater brain weight than two pounds, so his proportion will be greater. Also, it is true that on the average, the proportion of brain weight to weight of body in women is greater than it is in men. But any person of average body weight, say 140 to 150 pounds, is likely to have a proportion of brain weight not varying widely from one-fiftieth.

Third Line of Evidence.—A third reason for believing that the brain is more intimately connected with mental processes than is any other part of the body may be stated as follows: The brain of a human being manifests a greater degree of complexity than does that of any other animal. The thinking processes of man are more complex than are the thinking processes of any other animal. Hence we are inclined to believe that the complexity of brain structure is in some way related to the complexity of thought. Let us look at the brain to see how complex its structure is.

Parts of the Brain.—The brain is composed of three parts—cerebrum, cerebellum and medulla. In the brain of a fish, frog, and other animals not so complex as mammals, we find other parts of the brain that are very con-

spicuous. In the brain of a fish, two large, rounded lobes lie between the cerebrum and the cerebellum. These are known as the optic lobes and are perhaps of more importance to the fish than are the cerebral lobes themselves. In the frog and other animals we find two other lobes very conspicuous, lying in front of the cerebrum, from which nerves lead to the organs of smell. These are the olfactory lobes. We can find in the human brain the

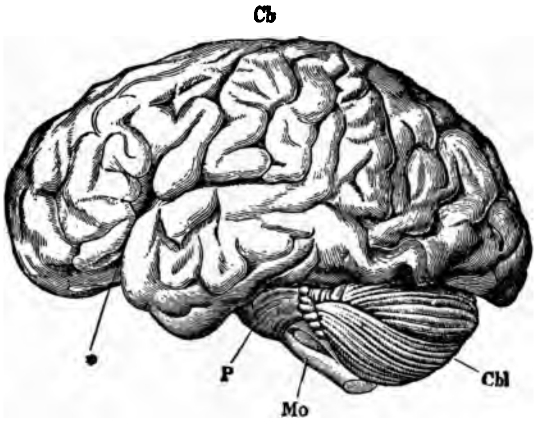


Fig. 1—The Brain: Cb, cerebrum; Cbl, cerebellum; Mo, medulla.

homologues of both the olfactory lobes and the optic lobes, but they are very small compared with the cerebrum.

The Cerebrum.—The cerebrum constitutes about seven-eighths of the brain, and greatly overlaps the other parts. The cerebrum is the part of the brain that is most intimately connected with mental processes, and for us it is the brain, although the other portions have their own functions without which mental and physiological processes could not be carried on.

The Hemispheres.—The cerebrum is divided into two parts, or hemispheres, by a deep fissure, or groove, which runs from the front to the back, and is called the longitudinal fissure. The two hemispheres are designated as the right and left, and the left is usually the larger. This is associated with the fact that the larger number of persons are right-handed. At the bottom of the longitudinal fissure is a mass of white fibers connecting the two hemispheres, and this portion is called the corpus callosum.

The Brain Membranes.—The surface of the brain is covered with a thin membrane which closely invests the brain substance, and is called the pia mater. The skull is lined with a tough, dense membrane called the dura mater. Between the pia mater and the dura mater is a very thin membrane, scarcely noticeable, called the arachnoid membrane, or spider web.

Convolutions and Fissures.—The surface of the brain is not smooth, but is ridged, and convoluted and thrown into folds. The grooves that run over the surface are called sulci, or fissures. Groove, sulcus and fissure are three words all meaning the same thing. Between the fissures are ridges, or gyri, or convolutions. Ridge, gyrus, and convolution are three words all meaning the same structural feature of the brain surface.

The Cortex.—In the brain we find two kinds of matter, gray and white. In the cerebrum, the gray matter is on the outside, and constitutes a layer about one-tenth to one-eighth of an inch thick. This layer of gray matter is called the cortex, and is believed to be the portion of the cerebrum that is most intimately associated with mental processes. It really constitutes the essential part of the cerebrum. It is a very complex structure, and a section of it shows five distinct layers of brain cells.

The Cortical Surface.—The cortex dips down into the

fissures, and thus its extent is about twice as great as it would be if the surface were smooth. It looks as if the folding of the brain surface were a device for furnishing to the cortex a greater surface over which it may be spread. It seems as if the cortex had expanded to such an extent that there was not room for it, and it had been crumpled and folded in order to adjust its great extent to the limited space inside the skull.

Fissure of Sylvius.—Some of the fissures and convolutions on the brain surface are important for us to notice. The largest and deepest fissure is the fissure of Sylvius. It begins on what we may call the lower edge of the brain and runs backward and upward. It seems to have been produced by the folding of one portion of the cerebrum upon another, and this is really the case. The portion of the cerebrum just below this fissure is called the temporal lobe.

Fissure of Rolando.—Another fissure that is of importance to us is the fissure of Rolando. This begins near the top of the brain and runs downward and forward. It is about three and a half inches long, and is of importance to us because it constitutes the axis of the motor area of the brain. Whenever a muscle of the body is moved, the nervous impulse that causes the muscle to contract starts from some place in the brain, one side or the other of the fissure of Rolando.

How Located.—We may indicate the position of the fissure of Rolando from the outside of the skull in the following manner: Draw a line on the skull from the glabella, which is the point at which the nose seems to begin, backward to a rounded prominence at the base of the skull, which is called the inion. Mark a point half an inch back of the middle of this line.

Next take a piece of paper with a square corner, pre-

senting an angle of ninety degrees, and fold this angle into equal parts; each part then has an angle of forty-five degrees. Fold one of these forty-five degree angles into two parts each of which will be twenty-two and a half degrees. One angle of forty-five and one of twenty-two and a half makes an angle of sixty-seven and a half degrees.

Place the point of the paper so folded at the point half an inch back of the middle of the line joining the glabella

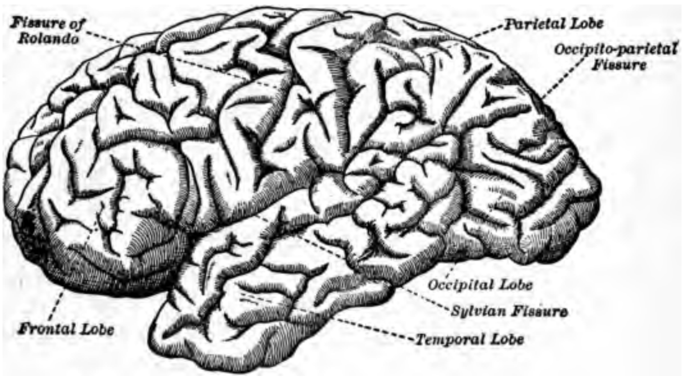


Fig. 2—The cerebrum, showing the fissure of Sylvius, fissure of Rolando, and the four lobes.

and the inion, placing the straight side of the paper on the line, and the other edge will project downward and forward at an angle of sixty-seven and a half degrees. This will indicate the position of the fissure of Rolando.

The Lobes of the Brain.—These two fissures enable us to indicate the grand divisions of the surface of the hemispheres. The portion of the cerebrum below the fissure of Sylvius is called the temporal lobe. The portion in front of the fissure of Rolando is called the frontal lobe. The portion of the cerebrum at the back of the

brain is called the occipital lobe. The portion in front of the occipital lobe and behind the fissure of Rolando is called the parietal lobe. There is no definite line or fissure marking the parietal lobe off from the occipital lobe, nor is there any fissure that will clearly indicate the boundary line between the temporal and the occipital lobe, nor between the temporal and the parietal.

SIDELIGHTS

Surely no one who is cognizant of the facts in the case nowadays doubts that the roots of psychology lie in the physiology of the nervous system.—*Huxley, Hume, p. 94.*

The laboratory is the forecourt of the temple of philosophy, and whoso has not offered sacrifices and undergone purification there has little chance of admission to the sanctuary.—*Huxley, Hume, p. 61.*

We study psychical variations indirectly by the aid of physical variations that can be studied directly.—*Ribot, German Psychology, p. 10.*

Men profoundly ignorant of the organism have had no hesitation in theorizing upon its highest functions.—*Lewes, Problems of Life and Mind, Second Series, p. 1.*

Although we cannot imagine how a nervous state (neurosis) gives rise to a conscious state (psychosis) we do know this. That distinct phenomena of consciousness never come under our observation apart from a nervous system, and so are presumably in some way endowments of it. We are therefore justified in calling them properties of the nervous system.—*Martin, Human Body, p. 461.*

It is absolutely futile to attempt to study the phenomena of mind without studying at the same time its bodily concomitants.—*Bolton, Principles of Education, p. 239.*

Dr. Carpenter has put it, "So long as either the mental or bodily part of man's nature is studied to the exclusion of the other, it seems to the writer that no real progress can be made in psychological science."—*Bolton, p. 240.*

DEFINITIONS

Cortex.—The outside layer of gray matter of the cerebrum.

Cerebrum.—The largest of the three divisions of the brain.

Cerebellum.—The little brain; the second division of the brain.

Fissure.—A groove, or depression upon the surface of the cerebrum.

Convolution.—A ridge, or portion of the cerebral surface between two fissures.

Glabella.—The place at the front of the skull at which the nose seems to begin.

Inion.—The rounded prominence at the base of the skull behind.

Corpus Callosum.—A mass of connecting fibers at the bottom of the longitudinal fissure connecting the hemispheres.

Hemisphere.—One of the two divisions of the cerebrum.

Fissure of Sylvius.—The largest and deepest fissure of the cerebrum.

Fissure of Rolando.—The fissure on the side of the cerebrum that constitutes the axis of the motor area.

Pia Mater.—The membranous covering of the brain.

Dura Mater.—The membrane lining the skull.

Arachnoid.—The spider-web-like membrane lying between the pia mater and dura mater.

CHAPTER II

Localization of Function

Localization of Function.—Our fourth reason for believing that mental processes are more intimately connected with the brain and nervous system than with any other system of organs in the body, is found in the doctrine of localization of function. Briefly stated, this doctrine asserts that every portion of the brain has its own function to perform, and that no other portion can or does perform that function. It asserts that for every mental process there is a corresponding physiological change which occurs in some particular portion of the brain and not in a different portion. It asserts that the same mental process is always accompanied by the same physiological change in the same portion of the brain.

The Doctrine Recent.—This doctrine is a matter of comparatively recent demonstration. Formerly, it was asserted that whenever a mental process was experienced the whole brain worked, and that it was impossible to conceive of merely a portion of the brain's being involved. However, the fact that the brain manifested different parts seemed to indicate that the different portions were likely to be associated with different functions. The text-books on physiology that were made and in use fifty years ago taught that the cerebrum was the portion of the brain immediately concerned in the intellectual processes, that the cerebellum was chiefly concerned in movement, while the medulla presided over the vital functions: heart beat, respiration, digestion, etc.

Stimulation.—There are four distinct lines of evidence by which the doctrine of localization of function has been established. The first consists of the results of experiments upon the brains of monkeys. The brain of a monkey is so nearly like the brain of a human being that what is true of a monkey's brain may be assumed to be true, with modifications, of the human brain. A monkey is chloroformed, the brain exposed, and the pole of an electric battery is applied to a small spot on the surface of the brain. If the pole is applied to some portions of the brain, there will be no indication of any change; but if it is applied to a spot in the Rolandic area, there will be a movement of some part of the body. If the pole is applied to a spot near the lower part of the fissure, some muscle of the face will move. In this way the whole Rolandic area has been mapped out, and the center for almost every muscle has been determined.

To What Applicable.—This method is applicable to the determination of the motor centers, but not to any other. If the pole of the battery were applied to some spot in the sight center, there would be no way of telling whether the monkey were seeing or not. Nor, if we were to suppose that there is a memory center, when the pole of the battery should be applied to it, would there be any way of indicating that the monkey remembered.

Hospital Cases.—The second line of evidence is derived from the records of hospital cases. As soon as the monkey's brain had been mapped, physicians, or surgeons, began to apply the results to the treatment of cases of brain disease. Not many years ago, it was believed that a mere puncture of the brain was sufficient to cause death. Now it is known that the brain may be cut and portions of it removed with less danger than attends an operation upon the abdominal organs. We have re-

ports of thousands of cases in which surgeons have diagnosed a disease from the derangement of some muscular function, and have cut into the brain, removing tumors, clots of blood, or pieces of bone. A single case will suffice as an illustration, a popular account of which will be found in Harper's Magazine for June, 1893.

The Mill Girl Case.—In 1891, a mill girl in Philadelphia was treated by a physician for epilepsy. She had a fit several times a day. She knew when a fit was coming on by a numbness which appeared first in her right thumb, then spread to her arm, soon after which she would become unconscious. Before she began to have fits, she had a numbness in her thumb, which gradually became more pronounced until the fits began to appear. The surgeons reasoned as follows: "The cause of the fits is a disease in the brain. Evidently the disease began in the thumb center, although it has now doubtless spread to surrounding centers. If we can cut out that portion of the brain which constitutes the thumb center we shall remove the portion that is most seriously diseased, and will alleviate, even if we do not cure, the disease."

Delicacy of Determination.—They located the fissure of Rolando, removed a button of bone, exposed the brain in the region in which they knew the thumb center must be situated, and then proceeded to determine accurately its position. It was the right thumb, so the left side of the skull was opened. The pole of a battery was applied to various places until the thumb center was definitely determined. It was necessary to be thus accurate in its determination, for if the cut should be made too far in one direction, the entire hand would be paralyzed, and the girl unable to continue her work. If it was made too far in the other direction, the organs of speech would be

paralyzed and the girl would be unable to talk, and that would be an exceedingly serious matter for any woman.

Effect of the Operation.—A small portion of the cortex corresponding to the thumb center was removed, the pole of the battery applied to the edges of the cut until it was certain that all of the thumb center was gone, while the hand and speech centers were intact, the wound was closed up and the girl recovered. While before the operation she had several fits a day, after the operation she had a recurrence of only seven fits in eight months.

Recovery of Function.—She resumed her work. At first her thumb was completely paralyzed, but in the course of several months, she gradually recovered the power to use it. This peculiar phenomenon is sometimes adduced as an argument against the truth of localization. There are several possible explanations of the recovery of function, none of which is perfectly satisfactory. The first and the most natural one is that cells that have been removed by the operation were replaced by growth, as a portion of the skin will be restored when it has been removed. This explanation is obviously not the correct one, for nerve tissue when once destroyed will not be regenerated.

Explanation of Recovery.—The second supposition is that when the thumb center on the left side of the brain had been removed, the corresponding center on the right side took up the function of that on the left. This is almost certainly not true. The third supposition is that some undeveloped cells in proximity to the center that has been removed become developed, form a connection with muscles whose nervous connections have been cut away, and really constitute a new center. This is the

most probable of the three suppositions, although it is not perfectly satisfactory.

The Importance of Such Cases.—The importance of this case and of others like it, is that the determination of the particular center was made with such exceeding nicety, and its strength in the argument is that such a fine determination would have been impossible if the theory of localization had not been true.

Extirpation Experiments.—The third line of evidence is that which is derived from extirpation experiments. These experiments have been made upon various animals, principally dogs. The skull of a dog is opened, and some portion of the cortical surface is removed. The dog recovers from the operation, and then he is observed in order to discover what mental functions have been lost. If the portion of the cortex that has been removed constitutes the center for sight, the dog will be blind; if for hearing, he will be deaf, although the eye and the ear will be in as good condition as they were before. This method is best adapted to the discovery of the sense centers, which the study of the monkey's brain by the method of electrical stimulation is not adapted to, although the extirpation method may be employed satisfactorily to locate the motor centers.

Aphasia.—The fourth line of evidence is that derived from certain forms of disease called aphasia. Aphasia is a disease characterized by an inability to speak certain words, or classes of words, or any words. The meaning may be understood, and the person may be able to write the words. There may be no paralysis of the vocal organs, but the patient loses the ability to speak certain words. In some cases it is the ability to write the words that is lost, while they may be spoken and understood. It is then called agraphia. Again it appears to be an

inability to hear or to understand any of the words. The general name for this disease is amnesia.

The Speech Center.—In all cases of aphasia, when there is an opportunity to make an examination, there is found to be a diseased condition of the brain in the region known as the speech center near the lower end of the fissure of Rolando, in the left hemisphere. This fact, that the diseased portion is in the left hemisphere, is probably associated with the fact that nearly all persons are right-handed.

Localization Demonstrated.—Putting together the evidence derived from these four lines of investigation, the truth of the doctrine of localization seems to be placed beyond dispute. We shall see, however, that there are many modifications that must be made, and that there is a very true sense in which we may say that the whole brain is concerned in every mental operation.

The Motor Area.—Let us now discuss what has been learned about the location of different centers in the brain. The motor area has been determined with a great deal of accuracy, and lies along both sides of the fissure of Rolando. The centers from which start the impulses that move the legs are situated near the top of the fissure. Along the middle course, lie the centers for the arms, while those for the head and face lie near its lower extremity.

The Sight Center, Hearing, Taste and Smell.—The sight center lies in the posterior portion of the cortical area, in the occipital lobe. Whenever a person sees anything, a nervous impulse is transmitted through some combination of cells in this region. Just below the fissure of Sylvius, in the temporal lobe, in what is known as Wernicke's convolution, is the area for hearing. Whenever a person hears anything, a nervous impulse is trans-

mitted through some combination of cells in this area. In the lower portion of the temporal lobe, farthest away from the fissure of Sylvius, is the center for taste and smell. The difficulties of locating this area are much greater than in case of sight and hearing, and the determination consequently cannot be accepted with the same degree of confidence. However, we may believe that the determination has been accurately made until the conclusion has been shown to be wrong.

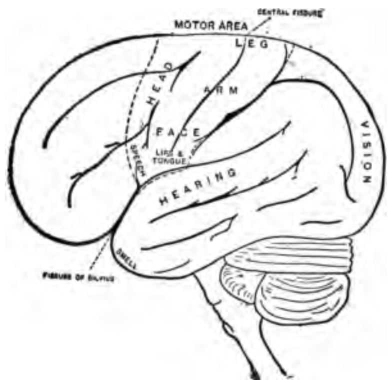


Fig. 5—Diagram of the brain showing location of motor centers, speech centers, centers for hearing, sight and smell.

The Speech Center.—Just above the fissure of Sylvius, at the lower end of the fissure of Rolando, in close proximity to the motor area, if indeed not a part of it, is the speech center. This speech center is functional only on one side of the brain, which in nearly all cases is the left side.

Other Sense Centers.—These centers are the only ones in whose determination we can place much confidence. Other centers have been determined, but the evidence for their location is not very conclusive. Just

behind the motor area, and probably overlapping it, is believed to lie the center for the sensation of touch. Probably also in the same area, or close to it, lies the center for temperature. From the conclusions reached in the attempt to locate the different centers, we may confidently believe that every sensation has its own center, although it may be a long time before the definite location of some of them will be discovered.

Association Areas.—When we have subtracted from the cortical surface all the portions whose functions we know, such as the sight center, the hearing center and the motor center, there are large areas for which no function has been definitely determined. Between the sight center and the center for touch and movement is a large unexplored area. In the frontal lobe is another. These are sometimes called association centers, and it is believed that nervous impulses from different sense centers enter into combination here. Also some have assumed that these are the areas in which the thinking is done, and Haeckel has called them the phronema, or thought portion of the brain.

Association Areas Problematical.—All such determinations are extremely problematical and cannot be accepted as definitely established. It can be shown that there are no higher processes of thought than those which accompany the transmission of different nervous impulses from one portion of the brain to another. Hence, while we may call these association areas, we should be careful not to imply that we really know anything at all about their especial functions. It would be just as well to call them unexplored areas.

SIDELIGHTS

If, as has been set forth in the preceding chapter, all mental states are effects of physical causes, it follows that what are called mental faculties and operations are properly cerebral functions, allotted to definite, though not yet precisely assignable parts of the brain.—*Huxley, Hume, p. 105.*

There is strong reason to believe that, corresponding to the four primary taste sensations, there are separate centers and nerve fibers, each of which when excited gives rise only to its appropriate taste sensation.—*American Text Book of Physiology, Volume II, p. 412.*

In a good brain or a good machine power may thus be developed over a large surface and applied to a small one.—*Stanley Hall, Adolescence, Volume I, p. 163.*

The psychologist who has not prepared himself by a study of the organism has no more right to be heard upon the genesis of the psychical states, or of the relations between the body and the mind, than one of the laity has a right to be heard upon a question of medical treatment.—*Lewes, Problems of Life and Mind, Second Series, p. 4.*

Observation and experiment of the kind that we have been considering seem to have established beyond serious question the doctrine of the localization of cerebral function.—*McDougall, Body and Mind, p. 104.*

DEFINITIONS

Localization of Function.—A theory that every portion of the brain performs its own function, which is different from that performed by every other portion.

Brain Center.—A portion of the cortex that is concerned in one function. A particular combination of brain cells traversed by a single impulse.

Motor Area.—That portion of the cortex from which impulses proceed to the muscles, producing movement.

Sight Center.—That portion of the cortex in which are located the combinations of cells traversed by an impulse when the sensation of sight is experienced.

Association Area.—One of the several areas of the cortex not included in the sense centers, in which some believe the different sensation impulses meet and mingle.

CHAPTER III

The Nervous System

Spinal Cord and Medulla.—The spinal cord is a continuation of the medulla; or perhaps it is easier to think of the medulla as being that portion of the spinal cord which lies within the skull. This statement will help us to think of the relation of the two organs to each other, although it is not strictly accurate. The spinal cord is from fifteen to eighteen inches long, and lies in a canal of bone formed by the backward extending processes of the several vertebrae that make up the spinal column. The spinal cord does not run through the vertebrae, but lies behind the centra, which we may consider to be the vertebrae themselves, and the canal in which it lies is formed by processes arising from the centra.

Two Enlargements.—If we examine the spinal cord after having removed it from the cavity in which it lies, we shall find two enlargements along its length. One is the cervical enlargement, about on a level with the shoulders and neck, and is the portion of the cord from which proceed the nerves that go to the arms and shoulders. The other is the lumbar enlargement, and is the portion from which start the nerves that run to the legs.

Anterior and Posterior Fissures.—The spinal cord is divided into two parts by two longitudinal grooves, or fissures: the anterior fissure, running along the front, or ventral side of the cord; and the posterior, along the back, or dorsal side. The two fissures divide the cord into a right and left half, which are connected by a por-

tion of the nervous matter extending from right to left sides. The anterior fissure is broader and not so deep as the posterior.

Arrangement of the Gray Matter.—The spinal cord is composed of gray and white matter, as is the cerebrum; but in the cerebrum the gray matter is on the outside,

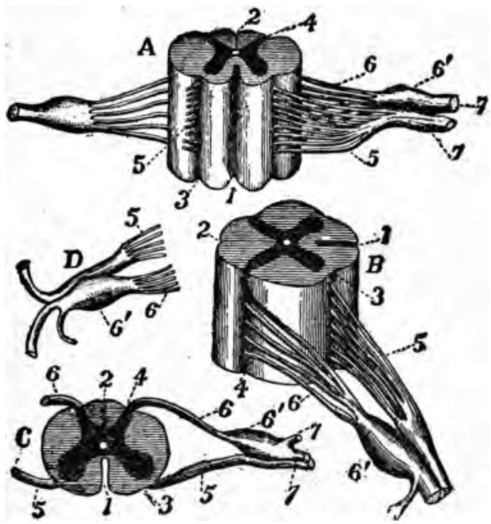


Fig. 6—Sections of the spinal cord showing the arrangement of the gray matter, the cornua, origin of the spinal nerves, nerve roots and sensory ganglia.

while in the spinal cord it is within. If we look at a cross section of the spinal cord, we shall see that the gray matter is arranged in a figure somewhat resembling the shape of the capital letter H. The extremities of the vertical bars of the H are called the horns of the gray matter, or cornua. The front horns are more rounded, blunt, and do not come so near to the surface of the cord as do the posterior horns.

The Spinal Nerves.—In the skull are twelve pairs of cranial nerves, some of which are exclusively sensory, such as the optic and olfactory nerves. The head and face muscles are supplied with nerves that originate in the medulla. From the spinal cord start out thirty-one pairs of spinal nerves, which run to all parts of the body below the head. Each pair consists of a right and left nerve, leaving the cord at the same level.

The Nerve Roots.—Each spinal nerve leaves the cord by two roots, an anterior and a posterior root. The anterior root originates in the anterior horn of the gray matter, while the posterior root originates in the posterior horn. The anterior root contains fibers that go to the muscles, and an impulse passing along the fibers of this root causes the muscles to contract, producing motion. On account of the movement produced by it, it is called the motor root. Since it starts from the anterior horn, it is called the anterior root; and since the impulses it conveys run outward, from the cord, it is called the efferent root. Anterior, motor, efferent are three names applied to the same root, although each word indicates a different aspect of the root.

Difference of the Two Roots.—The posterior root sends its fibers mostly to the sense organs in the skin, or on the outside, periphery, of the body. Since it starts from the posterior horn, it is called the posterior root. Since the impulses it conveys run inward, from the periphery of the body to the spinal cord, it is called afferent; and since the impulses it conveys accompany sensations, it is called the sensory root. Posterior, sensory, afferent are three terms all applied to the same root.

The Sensory Ganglion.—The roots of the nerves do not leave the cord as a single trunk, but each root consists of several or many fibers, or small nerves. The

several fibers and small nerves coalesce into a single trunk, and the two roots combine to form a single nerve. On the posterior root, close to the point of its junction with the anterior, is a small knot of nervous matter, called the sensory ganglion. No such structure occurs on the anterior root. After the nerve has been formed by the junction of the two roots, it begins to send off branches to the various parts of the body, each branch dividing and subdividing until the nerve is distributed to the entire region to which it goes.

Effect of Severing the Roots.—If the sensory is cut without interfering with the motor root, all sensation will

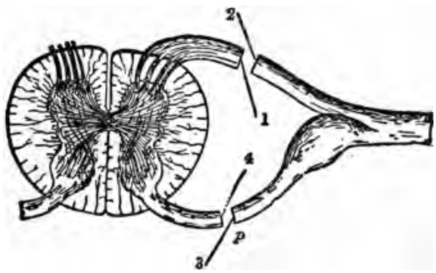


Fig. 7—Spinal cord and nerve roots. Effect of cutting the roots separately.

be destroyed in that part of the skin to which the sensory fibers are distributed, without impairing the ability to move the muscles with which the motor root is connected. Similarly, if the anterior root is cut, the sensibility will be retained in the skin to which the sensory fibers are distributed, but all power to move the muscles with which the motor fibers are connected will be lost.

The Nerve.—The nerve itself looks like a white cord; but instead of being a single cord it is a collection, or aggregation, of very fine threads of nervous matter which are called fibers. Each fiber is continuous throughout its

whole length, which in some cases may be as much as two or three feet, although by far the larger number of fibers are much less. The fibers themselves do not branch, but the different fibers that constitute the nerve separate, so causing the nerve to branch.

The Nerve Fiber.—The essential part of the nerve fiber is the axis cylinder, consisting of semi-fluid protoplasm, and which constitutes the conductor of the impulse. The axis cylinder is surrounded by a white membrane called the medullary sheath, which disappears near each extremity of the fiber. Its function is not positively known, but the best hypothesis about it is that it serves as a kind of insulator, preventing the nervous impulse from leaving the axis cylinder.

Neurilemma.—Outside of the medullary sheath is a thin membrane called the neurilemma. The entire number of fibers in a nerve are held together by connective tissue, and surrounded by a nerve sheath, or perineurum.

Transmission in a Fiber.—A nerve fiber will transmit an impulse in either direction. The reason why we speak of afferent and efferent fibers is because the impulses that the sensory fibers transmit are started in the ends of fibers farthest from the spinal cord, while the motor impulses originate in the cortex, or in the gray matter of the cord.

Neurons.—The essential elements of the brain cortex consist of ganglion cells, or neurons. The principal part of a neuron is the cell body, inside of which is a nucleus, and enclosed in that is a smaller body called the nucleolus. The nucleus constitutes the essential part of the cell, and when the cell becomes fatigued it is the nucleus that changes its shape and becomes smaller.

The Dendrites. — From the cell body proceed branches, or roots, called dendrites. These dendrites

branch freely, at acute angles, like the branches of a tree. The word dendrite is derived from a word that means tree. They are not separated by partitions from the cell body, but constitute a portion of the cell mass. Some cells have dendrites that are much longer and more numerous than other cells, and the difference between a

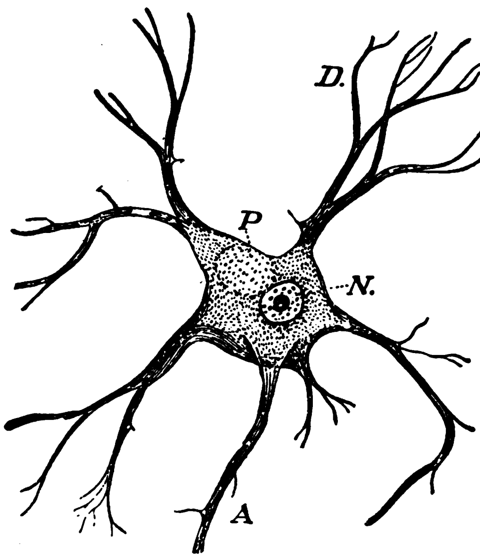


Fig. 8—A neuron showing cell body, dendrites, axon. A is the axon, D are dendrites.

developed and an undeveloped cell is seen most clearly in the number and extent of the dendrites.

The Axon.—One branch of the cell differs considerably from the other branches. It does not branch so freely, and the branches that it does send off proceed from it at right angles. This branch is called the axon, and its continuation becomes a nerve fiber. Every nerve

fiber is the axon of some cell. The name axon is intended to mean the same thing as axis cylinder.

The Neuron.—The entire cell structure, with the cell body, nucleus, nucleolus, dendrites and axon is called a neuron. Every neuron is independent of every other neuron, so far as physical contact is concerned. In only

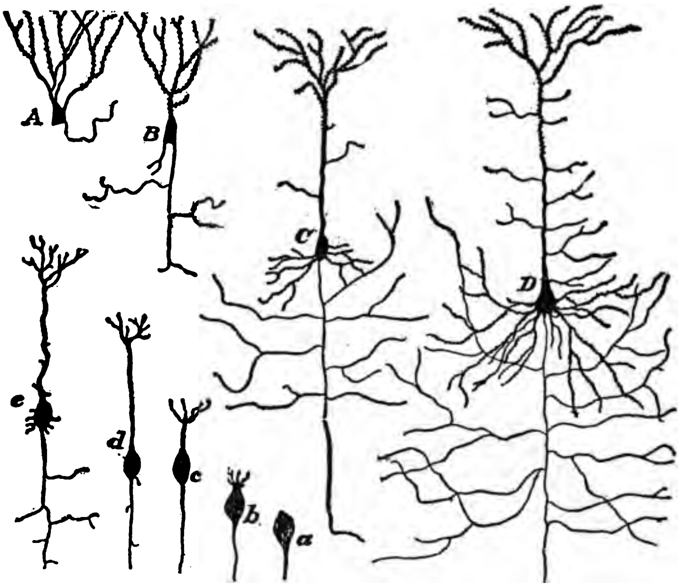


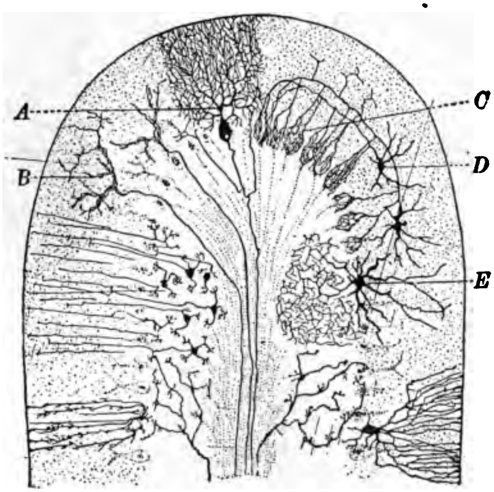
Fig. 9—Different kinds of neurons. A, from the brain of a frog; B, lizard; C, rat; D, man; a, b, c, d, e represent different stages in the development of a single neuron.

a few cases is there any direct physical contact between any neuron or its branches and those of any other neuron.

Neuroglia.—Surrounding the cells, and constituting a kind of packing material, is a substance called neuroglia. Besides holding the cells in place as packing material, the neuroglia furnishes an insulation which serves to prevent a nervous impulse passing from one

cell over into another except under proper conditions. While the neuroglia is nervous material, its function is subsidiary to that of the neurons.

The Gray Matter.—The neurons constitute the essential part of the gray matter. It is their presence that makes it gray. The white matter is composed principally of fibers, and it is the fibers that make it white.



CELLS IN THE CEREBELLUM

Fig. 10—Different kinds of neurons found in the cerebellum.

The white appearance is given to it by the medullary sheath, for if it were only the axis cylinder that showed, it would in all probability present the same gray appearance that is shown by the rest of the neuron.

Difference Between Fibers and Cells.—The fibers transmit impulses only. The neurons, or cell bodies, not only transmit impulses, but liberate energy and originate impulses. All the nervous energy that is liberated comes

from the neurons, or ganglion cells. There is little or no nervous energy produced in the white substance of the brain. There is much oxidation of tissue in the ganglion cells of the gray matter, but little oxidation occurs in the fibrous white matter. It follows also from this that there is little fatigue of the nerve, while the ganglion cell becomes easily fatigued.

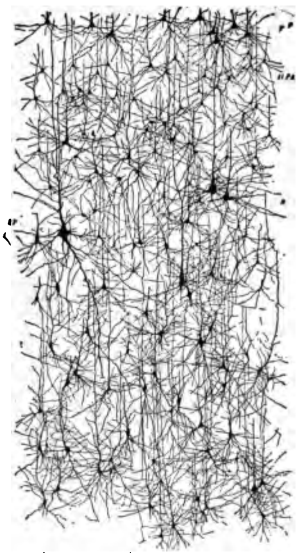


Fig. 11—General appearance of the neurons with their dendrites as they are embedded in neuroglia.

Number of Neurons.—The number of ganglion cells is very great. Seven hundred million is a low estimate, while other estimates run from ninety-two hundred million to thirteen billion. The difficulty in counting them is so great that it is not strange that estimates vary widely.

Direction of the Impulse.—It is believed that a ner-

vous impulse always enters a neuron by way of a dendrite, and leaves it over the axon. It is believed that the impulse will not travel in the other direction. The statement of this fact is known as the Bell-Magendie law, or the law of the forward conduction of the impulse.

The Bell-Magendie Law.—It may be questioned whether the law is universally true. If it is true, it appears that the blocking of the backward flowing impulse does not occur in the cell body nor in the axis cylinder, which are perfectly indifferent structures, so far as conduction is concerned. But the blocking of the impulse occurs in some way at the point where the transmission of the impulse from one cell to another occurs, which is the point where the axon of one cell and the dendrite of the other most nearly approach each other. This point of nearest approach is called the synapse, and is the point at which exactly occurs the process which is the concomitant of the mental process. It is here that the physiological change occurs that invariably accompanies the mental process.

The ganglion cells, or neurons, are the portions of the nervous system most immediately concerned in mental processes, and the physiological changes that accompany mental processes always are associated with the ganglion cells. Thus we have traced the mental processes to their association successively with the nervous system, the brain, cerebrum, cortex, gray matter, ganglion cells, and lastly we locate it definitely at the synapse.

SIDELIGHTS

It might be said that the need for a visible image of the mind is actually met by nature in the method of function of the nervous system.—*Höffding, Psychology, p. 50.*

The modern study of the functions of the mind has shown beyond all question that these are dependent upon the functions of the body, especially of the nervous system.—*Metchnikoff, Nature of Man, p. 159.*

We must content ourselves at present by considering it highly probable that every process of thought has a physical aspect, even though we are very far as yet from being able to trace it out.—*Karl Pearson, Grammar of Science, p. 47.*

In the absence of a nervous system we have no right to look for its product, consciousness.—*Huxley, Hume, p. 126.*

If, on the other hand, we make up our minds to consider nervous processes as the actual condition of centrally excited sensations, we have the advantage of being able to explain all the facts, in principle at least, without putting pressure upon them, or shifting our point of view. We also reap the benefit of basing theory upon a universal law of nervous structure and function which obtains, whether or not there are psychical phenomena to accompany the excitation. It cannot be charged against such explanation that it is either arbitrary or hypothetical.—*Külpe, Psychology, p. 219.*

We may represent the nervous system most clearly as itself a colony of some eleven thousand million amoeba-like organisms crowded together for the most part within the bony wall of the skull and the spinal column, with prolongations extending to all parts of the organism.—*Pillsbury, Essentials of Psychology, p. 23.*

Duval asks if we must not admit that the cerebral neuron and its ramifications are not always comparable to an amoeba with its pseudopodia, these ramifications contracting and elongating under various influences and so producing more or less intimate contiguity of the cerebral neurons.—*Manaceine, Sleep, p. 52.*

DEFINITIONS

Neuron.—The ganglion cell with all of its branches and appendages.

Dendrite.—One of the branches of the neuron, or ganglion cell.

Axon.—The branch of the neuron which is continued as the axis cylinder of a nerve fiber.

Spinal Cord.—That portion of the nervous system outside of the skull, which is enclosed in a bony cavity formed by the vertebral processes.

Cornua.—The horns of the gray matter in the spinal cord.

Medullary Sheath.—The white covering of a nerve fiber.

Axis Cylinder.—The central portion of a nerve fiber, which is the conductor of the nervous impulse.

Sensory Root.—The posterior root of a spinal nerve leading from a sense organ.

Motor Root.—The anterior root of a spinal nerve, leading to a muscle.

Sensory Ganglion.—The knot of nervous matter on the sensory root.

Neurilemma.—The covering of a nerve fiber outside of the medullary sheath.

Perineurum.—The outside covering of the entire nerve.

Synapse.—The point at which the dendrite of one cell and the axon of another most nearly approach each other. The point at which the nervous impulse passes from one cell over to another.

Bell-Magendie Law.—A statement of the fact that a nervous impulse will pass in one direction only, and not in the opposite direction, along a nervous arc, or from one cell to the other. Called also the Law of Forward Conduction.

Neuroglia.—The packing material in which the neurons are embedded. It serves also as an insulator for the nervous arc.

CHAPTER IV

The Nature of the Nervous Impulse

The Dualistic Theory.—In our preceding chapters we have made the assumption that in some way mental processes are associated with nervous structure and with physiological changes. The nature of this connection we are unable to determine. Some persons, whom we may call dualists, believe that mind and body, mental processes and physical changes, are completely distinct from each other. They believe that the mind is one thing and the body is another. While the two things may be associated with each other, neither is absolutely essential to the other's existence. In fact, of the two, the body is of considerably less importance, the mind merely using the body as an instrument to produce changes in the material objects of the external world. The only physical or physiological changes that accompany mental processes are those which the mind produces in the body by its own self-activity.

The Monistic Theory.—On the other hand, there are persons whom we may call monists, who believe that mind and body are not two separate things, but merely different aspects of the same thing. Mind, or mental processes, is nothing more than a function of the body, depending upon and produced by the physiological activity of the organs of the body, particularly the brain.

Parallelism, or Correspondence.—Between these two opposing views we are unable to decide. Neither can demonstrate to the satisfaction of the other the truth of

his own contention. Hence it is necessary for us to adopt some kind of a working platform upon which both dualists and monists may stand. Such a platform we may find in the doctrine of parallelism, or correspondence.

What the Doctrine Asserts.—The doctrine of parallelism, or correspondence, asserts that for every mental process there is a corresponding physiological change. It will not do to turn the statement around and say that for every physiological change there is a corresponding mental process. There is a great deal of difference between a house dog and a dog house. There are many physiological changes that are not accompanied by mental processes. But when we experience a mental process, we may feel quite sure that some physiological change is occurring, and it is the same physiological change that accompanies the same mental process under all conditions. Hence, where we have found the physiological change occurring, we may be confident that a particular mental action is in progress; and while we do not know the nature of the connection, it assists us in understanding the mental process to picture its concomitant in physiological terms.

The Nature of the Correspondence.—The doctrine of parallelism makes no assertion concerning the nature of the connection between the mental process and the physiological change that accompanies it. The dualist will assert that the mental process is the cause of the physiological change, and will agree to the doctrine. The monist will assert that the physiological change causes the mental process, and also agree to the statement of the doctrine. But the doctrine itself implies neither, and may even assert that the parallelism is a purely accidental circumstance.

The Nervous Impulse.—The physiological change that accompanies the mental process, and which we may call its concomitant, always takes the form of the transmission of a nervous impulse through a nervous arc. A nervous arc in its simplest form consists of an afferent nerve, a ganglion cell, another ganglion cell, and an efferent nerve. There must be at least two neurons involved in the arc, and the number of cells in almost any nervous arc that is traversed when we experience a mental process is doubtless very large. Perhaps we shall have to reckon the number in hundreds of thousands for the arcs that are traversed when we experience most of our mental processes.

Chemical Composition of Nerve Tissue.—In order to understand the nature of the nervous impulse, it will be necessary to know as much as we can about the structure of the nervous tissue. Brain tissue is composed principally of four elements, carbon, nitrogen, hydrogen and oxygen. These are represented by the letters C. N. H. O. Besides these, several other elements exist in small quantities: phosphorus, sulphur, iron, calcium, sodium, potassium and possibly a few others. But these latter elements are insignificant in quantity, although perhaps the nerve tissue could not be nervous without them.

The enumeration of the chemical elements, however, gives us no notion of the nature of the nervous substance. The atoms and molecules of these elements may be combined in hundreds of different ways to produce as many different kinds of substances.

Nerve Substances.—We know that many different kinds of substances exist in the brain, but the difficulties of analyzing living tissue are almost insuperable. As soon as we undertake to manipulate living tissue accord-

ing to the methods of chemical analysis, the tissue is no longer living, and changes to a substance of an entirely different nature. Some of the substances that have been discovered in the brain are called cerebrin, lecithin, cholesterin, neurokeratin and protagon. It must not be understood that the whole brain is composed of these substances, for when all of these substances have been subtracted from the brain, a considerable portion is left, which is doubtless composed of many kinds of substances different from any of those named.

Complexity of Molecules.—These substances are very complex. By this it is meant that the molecule of each of these five substances is composed of a great many atoms. A molecule that is composed of a small number of atoms is simple, while one that is composed of a great many is complex. Common salt has a very simple molecule, composed of one atom of sodium and one atom of chlorine. Water has three atoms in the molecule, two of hydrogen and one of oxygen. Ammonia has four atoms in the molecule, three of hydrogen and one of nitrogen. Sulphuric acid has a rather more complex molecule of seven atoms, two of hydrogen, one of sulphur and four of oxygen.

Organic Substances.—Ordinary sugar is produced in the growth of sugar cane, or sugar beets, and has a molecule that is much more complex. Its molecule contains 45 atoms: 12 of carbon, 22 of hydrogen, 11 of oxygen. There are two very important observations to make in this connection. One is that such complex molecules as those of sugar are produced only by living beings, and are therefore called organic substances. The other is that substances which are composed of such complex molecules are easily changed, or decomposed. Decay is

one of the changes to which substances having such complex molecules are susceptible. If we dissolve salt in water, the solution will not spoil, nor change nor decay. The salt will still remain salt. But if we make a weak solution of sugar, the sugar will change first to alcohol and later to vinegar, if conditions are at all favorable.

Characteristics of Nitrogen.—Especially will these changes, including the change of decay, occur, if nitrogen is one of the elements which constitute the molecule. Nitrogen is an inert element. It can scarcely be made to combine with anything else. We may pass a draft of air through the furnace, and all the oxygen will combine with the glowing coal. But the nitrogen, which comprises about four-fifths of the air forced through the furnace, will pass over the white hot coal and not enter into combination with it under the most favorable conditions.

Nitrogen in Explosives.—There are compounds of nitrogen found in the earth, such as potassium nitrate and sodium nitrate, which are known as saltpeter, and we may take advantage of this laziness of nitrogen to make it useful. Nitrogen, when it is in combination, will let go of the things with which it is combined very readily. So we make gunpowder, using a compound of nitrogen, and at the slightest excuse, the nitrogen lets go of the thing with which it is combined, and we have an explosion, which is merely the liberation of enormous quantities of nitrogen gas. It is nitrogen that constitutes the explosive force of nitro-glycerin and of dynamite. In the same way, nitrogen readily lets go of any substance with which it may be combined in a nerve molecule, and we have a change, which in consequence of the similar cause of the change in gunpowder, is sometimes called an explosion of a nerve cell.

Nitrogen in Organic Substances.—Nitrogen forms a part of very many of the organic substances which constitute the body of an animal or plant, and which are produced by them. Hence we find that very many organic substances readily undergo changes, one of which is decay, or decomposition, although there are many other changes that organic substances undergo in the body of any animal or plant while it is still alive. Organic substances that do not contain nitrogen are not nearly so susceptible to decay as are those into whose composition it enters. Fats and oils do not contain nitrogen, and they do not readily decay. Lard, turpentine and linseed oil, although they are organic substances, and have complex molecules, are scarcely susceptible to decay.

Molecular Constitution of Nerve Substances.—Nearly all substances which make up the nervous tissue contain nitrogen, have very complex molecules, and are consequently easily changed in a great many ways. The substance cholesterin is believed to have a molecule composed of 74 atoms, which is almost twice as many as the molecule of sugar contains. Protagon is a substance that is believed to have a great many atoms in the molecule. It is difficult to determine accurately its molecular formula, but it is believed that each molecule contains 509 atoms; 160 of carbon, 308 of hydrogen, five of nitrogen, one of phosphorus and 38 of oxygen. A molecule as complex as this, especially if it contains nitrogen atoms, must be so unstable that it is almost constantly in a condition of change, and the amount of force necessary to bring about a change in it must be almost inconceivably small.

Nerve Molecules Easily Changed.—We may not be perfectly assured that we know exactly the molecular

composition of protagon; and it may be true, as has been suspected, that protagon is not a simple substance, but a mixture of two or three other substances. But the truth that we learn from all of our investigations, and our attempts to determine the chemical constitution of the brain, is that the nerve substances are composed of very complex molecules, and that they are exceedingly easy to become changed. Decay in a dead animal always begins with the brain.

Isomeric Change.—The change that a molecule of nervous substance undergoes in a living body is usually some kind of isomeric change. In an isomeric change, the number and kind of atoms in the molecule remain the same, but they take on a different arrangement, and maintain different relations to each other. If we think of the atoms at first as having a definite arrangement in the molecule, and then under the influence of some other circumstance rearranging themselves without leaving the molecule or adding another atom to it, we shall have an idea of an isomeric change.

A Chemical Change.—The ordinary chemical change is one in which the number and kinds of atoms that make up the molecule after the change are different from those which constituted it before. Usually in a chemical change some of the atoms in a molecule leave it, and their places are taken by other atoms from other molecules; but it is usually the case that the atoms which take the places of those that are liberated from the molecule are different both in number and kind from those whose places they usurp.

Illustration of Water.—Water exists as water, ice and steam. The chemical formula is the same in each, and there is no change in the molecule in changing from one state to the other. This will assist us in understanding

the difference that may exist in substances without any change in the constitution of the molecule, although in this case it is a change in physical state, not an isomeric change in the molecule. It is an illustration of an isomeric change, not an example.

Nervous Impulse an Isomeric Change.—The change that occurs in nervous tissue when a nervous impulse traverses it, must be some kind of isomeric change, as was pointed out by Herbert Spencer nearly sixty years ago. Among organic substances there are many examples of isomeric changes. The chemical formulae of the substances remain the same, but in some way the atoms rearrange themselves and the substance takes on new and totally different properties. In a molecule as complex as protagon, there must be opportunities for a hundred different changes, transforming it into a hundred different substances, and yet the molecule in each of the different substances will consist of exactly the same atoms that are found in any of the ninety-nine other substances.

Colloidal and Crystalloidal.—Nerve tissue in its ordinary form is a colloidal substance. When it undergoes the change that occurs in the transmission of a nervous impulse, it changes to a crystalloidal form. Colloidal and crystalloidal forms of matter differ in at least two respects; the name crystalloidal is applied in consequence of the fact that when it solidifies, the form of matter to which it is applied crystallizes, or takes on the shape of crystals. Water is a good example of a crystalloidal form of matter. Water crystals are seen in the snowflakes, the frost crystals on a window pane, or on the surface of a vessel of water when it freezes.

A colloidal form of matter will not crystallize when it becomes solid. The white of an egg is a good ex-

ample. This difference is of more significance than it at first appears to be.

Osmosis.—The most important difference between colloid and crystalloid is the fact that in solution a crystalloid will pass readily through a membrane, while a colloid will not. An easy experiment will illustrate the point. If the shell of an egg be broken at the large end without rupturing the lining membrane, and the egg be placed so that the broken end is in the water, the water will pass readily through the membrane into the egg, but the egg material, being colloidal, will not pass readily outward into the water. Pressure is therefore exerted upon the inside of the egg, and if the shell is broken at the top, some of the contents will be forced outward at that place. By sealing a glass tube to the shell at the top, the pressure may be measured by the distance up the tube to which the contents are forced.

Change From a Colloid to a Crystalloid.—The nervous matter in its ordinary state is a colloid. The crystalloidal form is the one that is necessary to permit any portion of it to pass through a membrane, and it may be a necessary condition for the influencing of a tissue by nervous force, that the nervous matter must be in a crystalloidal form. In order to make a muscle contract, the molecules of the nerve endings, where it enters the muscle, must have the crystalloidal form.

Energy Liberated in the Change.—When the nervous molecule does change, it must change back again in order to repeat the process. This change from a colloidal form to a crystalloidal and back again occurs from 10 to 20 times in a second. This means that a good deal of energy is expended in making so rapid changes, and this expenditure of energy is indicated in several ways.

There is a considerable amount of tissue oxidized, and a consequently large amount of waste matter to be excreted in the form of carbon dioxide and other waste products. Many years ago it was proposed to use the amount of phosphorus excreted as a measure of the amount of nervous energy expended, and those great scientific authorities, the newspaper men, widely advertised the fact that thought depended upon phosphorus, and that a diet rich in phosphorus was necessary to the production of thought. That is all there is to the phosphorus theory of thought, or a fish diet as brain food.

Loss of Tissue.—Not only can we detect a great oxidation of tissue in the brain cells, in association with nervous processes, but an actual change in the shape and size of the cell has been observed. This means that some of the substance of the cell escapes from its boundaries, and whether any of it goes off directly as a result of its becoming a crystalline form of matter, and by so doing affects other nerve cells and muscles and glands with which the nerve is connected, or whether the loss may be accounted for by the waste that is excreted, would be a difficult matter to determine.

What an Impulse Is.—But a mere change in condition does not constitute a nervous impulse. An impulse implies a change in successive portions of a conducting substance. In a nerve, the impulse, or current, consists of a change in successive molecules of the axis cylinder. One molecule changes, and as a result of this change, the molecule next to it changes, and this causes a third one to change, and so on until the last molecule in the nervous arc has been changed. The process is well illustrated by a row of bricks set up on end, and not farther apart than half the length of one brick. When the first brick in the row is toppled over,

it strikes the second in the row, knocking it down, and the fall of the second brings about the fall of the third, and so on until the last brick in the row is knocked over.

Fatigue of Nerve Molecules.—The nerve molecules are like the bricks in the row, except that when the nerve molecules have been changed, or knocked down, each one will get right up and be ready to be knocked over again. The process of getting up and being knocked down in the case of the nerve molecules goes on rather rapidly; from 10 to 20 times in a second. It is rather a vigorous process to be knocked down and get up so rapidly, so that the cells soon become fatigued and must rest for a time in order to recuperate.

Rate of Transmission.—It is evident from the illustration that the molecules do not all change at the same instant. One molecule must change before the second one can change. It is this succession in change that constitutes the impulse. It is evident, also, that the process takes some time. There is a measurable interval between the change in the first molecule of a nerve and the last molecule that is changed. We use the expression, sometimes, "As quick as thought." If by that expression we mean as quick as the nervous impulse travels, we do not mean any very great rate of speed. Sound travels at the rate of about 1,100 feet in a second; light moves at about 186,000 miles, eight times around the earth, in a second; electricity in a good conductor will go about as fast; but the nervous impulse lazes along at about 100 feet in a second, in a nerve, while in a brain center it goes not more than from one-tenth to one-twentieth as fast. If a man were 400 feet high, and should put his bare foot on a live coal, or a piece of red hot iron, it would be four seconds before he would feel any pain, or know that his foot were burn-

ing. Then he would start an impulse back to remove the foot from the hot iron; but as it would require four seconds for the impulse to reach the foot, the burning would continue eight seconds before the foot could be removed. We ought to be glad that we are not 400 feet high.

Transfer of Atoms.—It is possible that we may image the process that goes on in the molecule while a nervous impulse is in progress in such a way as to make its comprehension easier. We may invent some kind of hypothesis to account for the changes that occur. Let us

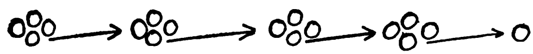


Fig. 12—Diagram showing the molecular changes in a nervous impulse. The arrow shows the position of the atom in the molecule from which it is driven, and the position it assumes in the molecule to which it goes.

represent a molecule of the axis cylinder by a group of atoms having a triangular arrangement with the apex at the right. Let us suppose this arrangement to represent the colloidal state of the molecule. Some force impressed upon the molecule A changes its shape in such a way that one atom leaves A, flies off to molecule B, striking it, changing its shape to triangular with the apex at the left, and driving off an atom to molecule C, and so on. The change in shape will correspond to the change from colloid to crystalloid. The molecule will contain the same number and kinds of atoms that it did before, but the atoms will have a different arrangement, and indeed they will not be the identical atoms that previously composed the molecule. In this respect our definition of an isomeric change will need modification.

Possibly of Corpuscles.—But we do not need to limit ourselves to the supposition that it is the atom that is

transferred from one molecule to the next. Formerly it was believed that the atom was a hard, incompressible, homogeneous thing, incapable of modification, and not composed of smaller elements. Now it is believed that every atom is composed of smaller parts, called corpuscles, or electrons, varying according to the kind of atom, and its atomic weight, from 1,000 to 200,000 in each atom, and moving within the atomic space at rates varying from 50,000 to 150,000 miles in a second. This gives each corpuscle, notwithstanding its small size, considerable force.

Instead, then, of its being an atom that is shifted from one molecule to another, thus making the nervous impulse, it is possible that it is the corpuscles of various atoms that are thus shifted. However, the shifting of atoms is easier for us to understand, and so long as it fills every requirement, we may adopt it as a hypothesis concerning the real change that constitutes the nervous impulse.

SIDELIGHTS

The problem, How does the Impulse find its way from A to B? is the crucial problem for physiological psychology.—*McDougall, Physiological Psychology, p. 126.*

Reverting then to the common hypothesis of a "nervous fluid," which moves in nerve "currents," admitting that though the molecular motion which works nervous effects is not a fluid, and its transfer is not a current, they may be conveniently dealt with as though they were.—*Spencer, Psychology, Volume I, p. 586.*

Experience shows that nerve force is generated and set free wherever the cerebro-spinal system is excited.—*Darwin, Expression of the Emotions, p. 349.*

According to this idea, living proteid does not need to have a constant molecular weight. It is a huge molecule and undergoing constant and never ending formation, and constant decomposition, and probably behaves toward the usual chemical molecules as the

sun behaves toward small meteors.—*Baldwin's Dictionary, Volume II, p. 9, Art. Living Matter.*

We may conclude from these experiments that the movement process of stimulation is relatively slow; for the frog nerve at ordinary temperatures it averages 26, for the nerves of warm-blooded animals at normal body temperature, 32 meters in one second. And second, that it consists in all probability, not in a simple transmission and propagation of the external stimulus movement, but in a chain of movement processes released from one point to another in the nerve itself.—*Wundt, Physiological Psychology, p. 69.*

The rate at which nerve cells discharge is about ten impulses per second.—*American Text Book of Physiology, Volume II, p. 189.*

DEFINITIONS

Nervous Impulse.—The change that occurs in successive molecules of a nervous arc.

Nervous arc.—The nervous pathway over which a nervous impulse is transmitted.

Molecule.—The smallest division of a substance that can be made and still manifest the properties of that substance.

Atom.—One of the constituent parts of a molecule.

Corpuscle.—One of the constituent parts of an atom.

Isomeric Change.—A change in the arrangement of the atoms in a molecule without any change in the number or kinds of atoms. The molecule may have different properties after the change from what it had before.

Colloidal.—A form of matter that does not crystallize upon solidification.

Crystalloidal.—A form of matter that does crystallize when it becomes solid.

CHAPTER V

The Sense of Sight

Sense Organ a Machine.—A nervous impulse is started by force from the outside, acting upon some sense organ especially adapted to the kind of force employed. The eye is an organ especially adapted to the force of light, and is the machine by which light establishes an impulse. We shall study it as an apparatus by means of which a nervous impulse is established.

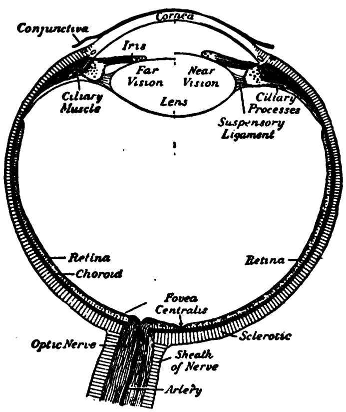


Fig. 13—Diagram showing parts of the eye.

Coats of the Eye.—The eye is essentially a globe, although the axis from front to back is somewhat longer than that from side to side. It is covered by three coats, the outer of which is the sclerotic, a dense, fibrous, inelastic membrane which holds the eye in shape. The

sclerotic coat does not extend completely around the eyeball, but in front its place is taken by a membrane called the cornea, which is transparent and constitutes the front surface of the eye. The sclerotic coat may be seen as the white of the eye all around the cornea.

The Choroid and Iris.—The second coat of the eye is the choroid, which is displaced in front by the iris. The iris is a colored membrane, and it is the color of the iris by which the color of the eye is designated. In the middle of the iris is a hole called the pupil. While the pupil is not really a part of the eye, it is such a conspicuous mark that we may consider it as if it were. The pupil is always black, because we see it as the opening into a dark cavity, from the inside of which little or no light is reflected. The pupil changes its size to correspond to the amount of light that enters it. When the amount of light available for seeing is small, the pupil enlarges so that as much as possible will enter. When the intensity of light is great, the pupil diminishes, thereby excluding an amount that might be detrimental to seeing.

The Change of Size in the Pupil.—The mechanism by which this change in size is brought about is found in two sets of muscles in the iris. One set runs from the edge of the pupil to the outer edge of the iris. These are the radial muscles, and when they contract they diminish the distance between the outer and inner edges of the iris, thus enlarging the pupil. The other set are the circular muscles, which run around the pupil. The effect of their contraction is to draw the edges of the pupil closer together, thus diminishing its size. These changes in the size of the pupil are involuntary and reflex. We can not will to make the pupil smaller or larger, but the stimulus to the muscle is found in the

light itself, thus regulating the size of the pupil and the amount of light that enters it automatically.

How Observed.—These changes in the size of the pupil may be observed by every one in his own eye. If one stands in front of a mirror in a darkened room, holding a candle, lamp or other source of illumination behind him, the pupil will become enlarged. Then bringing the candle in front so that its light will fall upon the eye, the rapid contraction of the pupil can be witnessed in the mirror.

Variation in Different Eyes.—The pupil in the human eye is circular, but in the eye of the cat the radial muscles are so attached that the pupil closes into the shape of a vertical slit. In the eye of the owl the circular muscles are incapable of sufficiently closing the pupil, so that the owl is almost blinded by day in consequence.

Detrimental Effects of Reading While Facing the Light.—It will be seen from this description of the method by which the size of the pupil is controlled that there is a serious danger in trying to read when facing the light. The light entering the eye from the source of illumination stimulates the circular muscles to contract in order to shut it out. The small amount of light received from the page which we are trying to read, and which is turned away from the light, stimulates the radial muscles to enlarge the pupil in order that a sufficient amount of light may be received from the poorly illuminated page. Thus the radial and circular muscles are acting at the same time in opposition to each other, and the result is a disastrous muscular strain.

The Retina.—The third coat of the eye is the retina, which is a nervous coat. The retina is a very complex organ, composed of 10 layers, only three of which may be considered as layers of neurons. There are in the

retina three layers of neurons in which the nervous impulse is started and by which it is transmitted. The rod and cone layer is the most important, and is the one farthest away from the center of the eye and nearest the choroid coat. It is called the rod and cone layer in consequence of the two kinds of elements that are found in it. It seems to be necessary for the light to pass through the rod and cone layer before an impulse can be established.

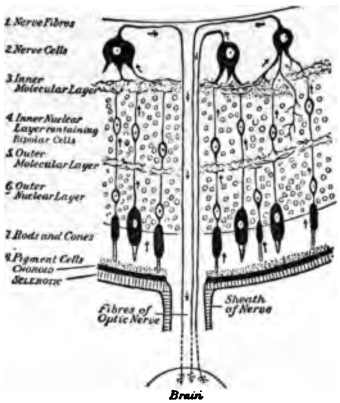


Fig. 14—Section of the retina showing three layers of neurons.

The Fovea.—The point which is immediately behind the pupil in the retina is called the fovea centralis, or macula lutea, or yellow spot. It will be convenient for us to speak of it as the fovea. It is the point of most acute vision, and is the spot on which we try to make the image of an object fall when we turn our eyes to an object. In this fovea there are only cones. In that portion of the retina farthest away from the fovea there are only rods, while in an intermediate zone there are both rods and cones.

The Blind Spot.—An impulse which is started in the retina reaches the optic nerve and is transmitted by that nerve to the brain. The point at which the optic nerve enters the eye, or comes into contact with the retina, is called the blind spot. It is a place in which neither rods nor cones occur, and an image of an object falling upon the blind spot establishes no impulse. In every field of vision there is a portion that is vacant, although it is difficult for us to realize that we are not seeing all that

Fig. 15—Diagram to demonstrate the blind spot. Hold the diagram perfectly horizontal, the head erect, close the left eye, look steadily at the cross, vary the distance of the diagram from the eye, and the white circle will disappear.

we think we see. The blind spot is on the side of the retina nearer the nose than is the fovea.

The Crystalline Lens.—Returning now to the front of the eye and enumerating the different parts that we encounter in passing from the front to the back, we find first, the cornea; second, a cavity that is filled with a watery fluid called the aqueous humor, which fills the cavity in which the iris is placed. Next we notice the iris and the pupil, after which we come to the crystalline lens. This is a double convex lens, rather more convex toward the back than toward the front. It is enclosed in a thin, transparent sac called the suspensory ligament. All around the edges of the suspensory ligament are fine

muscular fibers called the ciliary muscle, which by their contraction, stretch the suspensory ligament out at the edges, and tend to bring the two layers of it closer together at its center, thus making the lens which is enclosed within them flatter. This flattening of the lens is just the condition necessary to enable it to bring the rays of light that come from a distant object, and are therefore more nearly parallel than those which come from a shorter distance, to a focus on the retina. When we look at an object near by, the ciliary muscles are relaxed, and the elasticity of the lens restores it to its former convexity, which is the condition necessary to enable the rays of light from a near-by object to be brought to a focus on the retina.

Another Explanation.—The above is Helmholtz' explanation of the process of adjustment of the crystalline lens. It should be mentioned that another explanation of the action of the ciliary muscles is offered by other physiologists, in which it is the contraction of the muscles that renders the lens convex, and the relaxation that permits it to become flatter.

Vitreous Humor.—Behind the crystalline lens is a large cavity filled with a jelly-like substance called the vitreous humor. The word vitreous means glassy, and the vitreous humor is glassy and jelly-like, not at all like the aqueous humor. The other organ, which is really not a part of the eye at all, is the optic nerve.

We have now indicated 10 parts of the eye, or organs that are immediately connected with it. The sclerotic coat, choroid coat, retina, cornea, aqueous humor, iris, pupil, vitreous humor, crystalline lens and the optic nerve.

Luminiferous Ether.—The eye is the machine. The power that acts upon it is the force of light. It is by means of light that we see, and it is the light acting

upon the eye that establishes the nervous impulse. Light consists of vibrations in the luminiferous ether, which is an extremely thin and tenuous form of matter, that can not be detected by any of the senses. It can not be seen or felt or heard. The only way we become aware of its existence is by the behavior of other things. The presence of such a substance is necessary to enable us to explain the phenomena of light, radiant heat, electricity, and perhaps gravitation.

Light.—Luminiferous ether extends certainly as far as the most distant star that we can see, and we do not know how much farther. Light consists of waves in the luminiferous ether. The waves are transverse like the waves of water. If a ray of light is traveling across a room, the waves of which it is composed vibrate transversely across the path of the ray. The waves are very small. A ray of red light consists of waves that are about 1/33000 of an inch in length, and a wave of blue light is about 1/68000 of an inch. That is, in one inch there are about 33,000 red waves and about 68,000 blue waves. Waves of ether that are longer than 33,000 to the inch are not able to start an impulse in the retina, and waves that are shorter than 68,000 to the inch are equally ineffective.

Vibration Frequencies.—Light travels at the rate of about 186,000 miles in a second. If we multiply 186,000, the number of miles, by 5,280, the number of feet in a mile, and that product by 12, the number of inches in a foot, and that by 33,000, the number of red waves in an inch, or by 68,000, the number of blue waves in an inch, we shall find that not far from 392 trillion red and 760 trillion blue waves enter the eye in a second. Between these two extreme numbers are all the other vibration rates, and they correspond to the other colors.

Force of Light.—Light exerts a force on the surface upon which it strikes. The force exerted is very small; in case of sunlight it is scarcely more than a milligram on a square meter, but that force, small as it is, is sufficient to jar loose from the very complex molecules that constitute the nerve tissue of the retina, some of the atoms that compose it, thus originating a nervous impulse. The impact of the ether waves is sufficient to jar the molecules enough to drive off some of the atoms from their connections with the other atoms in the molecule, thus setting some of the atoms free, which immediately strike the next molecule, driving off from it other atoms, and taking their places. The atoms that are freed from the second molecule strike the third, setting some of its atoms free and taking their places.

It will be seen from this that the atomic constitution and structure of the first molecule may be changed, while the composition of the second and third remains practically unchanged, although some of the atoms may be different, and the arrangement is not the same.

Mechanical Theory.—The above may be called the mechanical theory of the origin of the nervous impulse. It is possible, of course, that instead of the atoms being driven away from the first molecule, their arrangement merely is changed. The first supposition seems more probable, for it is difficult to see how a mere change in the arrangement of the atoms of one molecule can bring about a rearrangement of the atoms in the second and third molecules with which it is not in immediate physical contact.

Course of Transmission.—When an impulse has been established in the neurons of the rod and cone layer, it is transmitted to the optic nerve, and from there it passes along the nerve and over different portions of the

nervous tract to the center for sight in the occipital lobe of the cerebrum.

The Chiasmus.—The impulse passes first over the optic nerve until it comes to a place where the optic nerves from both eyes join. This place is a kind of nervous knot called the chiasmus. From the chiasmus the nervous conductor proceeds backward as two nerves, but each is now called the optic tract, right and left, to

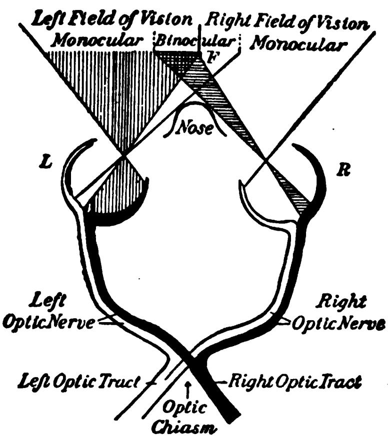


Fig. 16—Distribution of fibers from the optic tracts to the two retinae.

distinguish them from the right and left optic nerves. The impulse passes back over the optic tract until it reaches the brain in a portion that might be said to correspond to the optic lobe. In fact, however, the fibers of the optic tract reach three different organs, or portions of the brain; the external geniculate body, the anterior corpus quadrigeminum, and the pulvinar of the optic thalamus. From these organs, the impulse is carried by fibers back to the optical center in the occipital lobe.

Decussation of the Fibers.—There is one peculiar feature in the distribution of fibers to the retina. The fibers of the right optic tract divide in the chiasmus, some of them going to the right side of each retina, while the fibers from the left optic tract reach the left side of each retina. So each retina contains fibers from both tracts. If we were to sever the right optic nerve, we should be blind in the right eye, and would see perfectly well with the left. But, if we were to sever the fibers of the right optic tract, we should be half blind in each eye. We should be able to see any object that formed an image on the left half of the retina in either eye, but would be able to see nothing that formed an image on the right half of either retina.

In fishes and frogs the two optic tracts cross but do not form a chiasmus. There is no necessity for distinguishing the optic nerve from the optic tract. But in mammals, birds and reptiles a chiasmus is formed.

SIDELIGHTS

The human retina, he remarks (Max Schulte) is formed as it were of two associated retinae; that of the cones and that of the rods. The former yield the sensation of light and darkness, and, further, all the color sensations. The second supplies only the sensations of light and darkness.—*Morat, Physiology of the Nervous System, p. 261.*

The rods are found almost exclusively in the retinae of nocturnal animals. In most birds the cones predominate, or are alone present. —*Morat, p. 561.*

A microscopic examination shows that this coloring matter which has been termed visual purple is entirely confined to the outer portion of the retinal rods, and does not occur at all in the cones.—*American Text Book of Physiology, Volume II, p. 250.*

It is perhaps true that the rods act only when the light is dim, and give no sensations at all for green.—*Thorndike, Psychology, p. 27.*

DEFINITIONS

Eye.—The apparatus by which light establishes a nervous impulse.

Sclerotic Coat.—The outer one of the three coats of the eye.

Choroid Coat.—The middle coat of the eye.

Retina.—The interior, nervous, coat of the eye.

Iris.—The colored portion of the eye.

Rod and Cone Layer.—One of the three layers of neurons in the retina.

Blind Spot.—A spot in the retina where the optic nerve enters the eye, destitute of rods and cones, and in which light will not establish an impulse.

Fovea.—The center of the retina. The point of most acute vision, directly behind the pupil.

Light.—A series of transverse vibrations in the luminiferous ether, between 392 trillions and 760 trillions per second.

Crystalline Lens.—The principal refracting medium of the eye.

Ciliary Muscles.—The muscles that adjust the crystalline lens.

Optic Nerve.—The nerve that transmits impulses from the retina to the chiasmus.

Optic Tract.—That portion of the nervous transmitter that lies behind the chiasmus.

Chiasmus.—The nervous knot in which the two optic nerves meet.

CHAPTER VI

The Sensation of Sight

White Light.—Whenever a nervous impulse is established in the retina, or in any other part of the optic conductor, and is transmitted to the sight center in the brain, we experience the sensation of sight. When we look at a white card, or any other white object, we experience a sensation that we call white. When we look at the blackboard, we experience a different sensation that we call black. The white card is white because it reflects white light to our eyes. By white light we mean light that contains all vibration frequencies from 392 trillions to 760 trillions in a second. But the black object also reflects white light. In the light reflected from the blackboard will be found all vibration frequencies within the light limits. The difference is that the white object reflects more of the light that falls upon it than does the black object.

Difference Between White and Black.—An object that we call white reflects from 50 to 90 per cent of all the light that falls upon it. An object that we call black reflects from less than one-half of 1 per cent to something more than 2 per cent. If the black object should reflect no light to our eyes it would be invisible. If the white object should reflect all the light that falls upon it, without any change, it would be a perfect mirror and would itself be invisible.

Gray.—Black and white, then, while they are two distinct sensations, are merely the extremes of a series

of sensations accompanying impulses established by the reflection of various proportions of light of all vibration frequencies to our eyes. If the proportion of light becomes less and less, we cease to regard the body as white, and call it gray. We may have a light gray at first, and as we diminish the proportion of light that is reflected, the gray becomes less and less light until we say that it is a dark gray. If the proportion continues to decrease, the gray becomes darker and darker until we call it black. Somewhere in the series is a gray that we can call neither light nor dark gray. This might properly be termed neutral gray. It is possible for a good eye, well trained, to distinguish 200 degrees of intensity in the sensation from black to white, or 200 degrees of brightness.

Brightness the Original Sensation of Sight.—It is believed that in the beginning of sight, the first animals, and even the first men, could distinguish only black, white and gray. Men would then see things as a photograph shows them now. The perception of color came as a later acquisition. In fact, it is questionable whether little children, perhaps up till the age of 3 years, can distinguish color, and whether they do not see things as merely black, white and gray. So when we find persons that are color blind, and unable to distinguish color, we may explain it by supposing that they have inherited that ancestral condition.

The Solar Spectrum.—If we set a triangular prism of glass in the sunlight at a window, we may throw on the opposite wall a spectrum of color. There will be observed in this spectrum the seven so-called primary colors, beginning with red and running through orange, yellow, green, blue, indigo and violet. The prism separates the different colors according to the wave lengths

of light which compose them, or according to the vibration frequencies which they represent.

Number of Colors.—We ordinarily speak of only seven colors, but there is really no reason for limiting the colors to this number. Orange is certainly only a mixture of red and yellow, and there is no place in the spectrum for purple. The different colors are produced by different vibration frequencies, and there are many more than seven in passing from 392 trillion to 760 trillion. There is the possibility for as many different colors as there are vibration frequencies, but the eye is incapable of responding to such delicate differences as would be implied by this number. We shall find, however, that a good eye is capable of discriminating about 150 different colors, and this would mean that in order to constitute a difference in color, there must be a difference in vibration frequency of at least two and a half trillion vibrations per second.

Color Blindness.—Some persons can not distinguish color, and hence are called color blind. In much the larger number of cases the color blindness is only partial, being limited to one or two colors. The most common form of color blindness is the inability to distinguish red, although some persons are unable to distinguish either red or green or blue. About four men in a hundred are color blind, while there is a much smaller proportion of women.

Color a Function of the Cones.—It is possible to demonstrate that we are all color blind in parts of our eyes. If we look at a point on the blackboard steadily, while another person holds a card, having upon it a red spot, at one side of the point at which we look, the image of the red spot will fall upon the retina at various distances from the fovea. When the image falls upon the fovea,

we distinguish the color. When it falls upon some portion of the retina in the vicinity of the fovea, we are able to distinguish the spot, and to see its color. But if it is carried still farther to one side, the color disappears, while it may still be seen as a black or gray spot. The color is perceived only when the image falls upon that portion of the retina in which the cones are found. When it falls upon any portion in which only rods appear, no color is perceived.

Rods Adjustable for Dim Light.—We can see color clearly only in a good light. When we look at color in a dim light, it is difficult to distinguish red from green or blue or yellow, except as one is darker or lighter than the other. But we can distinguish objects readily, as black or white or gray, even when nearly all the light has disappeared. It seems as if in the rods there is some means for making wide adjustments for the small amount of light, while in the cones there is no such adjusting power. It is in consequence of this fact that we are able to perceive the faintest possible object, such as a faint star, not by looking directly at it, but by looking a little bit to one side of it. This is what the astronomer calls the method of averted vision.

Positive After Image.—If we look steadily at a lighted window from the inside of the room for one second, and immediately close our eyes, we shall have the image of the window persisting in our eyes for a few seconds. The window will appear just as it was in the original image; that is to say, the panes will be light and the sash dark. This phenomenon has been termed the positive image.

Negative After Image.—If we look steadily at the same window for about 20 seconds, and then close our eyes, we shall see an after image, but the conditions will

be reversed. The panes will appear dark and the sash will be light. This is called the negative after image.

Complementary Image.—If we look steadily at a red spot on a card for 20 seconds, and then with our eyes open look at a gray or white wall, we shall see a green spot of the same shape as the red spot. This is called the complementary image.

Hering's Theory.—In order to explain the phenomena of after images and complementary images, Hering supposes that there are three different kinds of substances in the eye. One kind he calls the white-black substance, not because it looks black or white, but because by its decomposition under the influence of light it gives us the sensation white, while by its recomposition after it has been decomposed, it gives us the sensation black. It is decomposed by white light, and is recomposed by the absence of light. If decomposition and recomposition go on at the same rate, at the same time, we experience the sensation of neutral gray. So any shade of gray, or any degree of brightness, is dependent upon the relative amount of decomposition and recomposition going on at the same time in the black-white substance.

Red-Green and Yellow-Blue Substance. — Another substance is the red-green substance, whose decomposition gives rise to the sensation of red and its recomposition to the sensation of green. The third is the yellow-blue substance, whose decomposition gives rise to the sensation of yellow, and its recomposition to the sensation blue. Any color with any degree of brightness may be accounted for by supposing that decomposition and recomposition are going on in all these substances at any time, in varying degrees and in varying proportions.

How Explain After Images.—The positive after image is seen because decomposition is going on in the black-

white substance for a little time after the light is shut off, and decomposition goes on more rapidly than recomposition. But after having looked at the window for a period as much as 20 or 30 seconds, so much of the black-white substance has been decomposed that when the light is shut off from the eye, recomposition proceeds more rapidly than decomposition in that portion of the retina on which the image of the panes fell; while in that portion of the retina on which the image of the sash fell the amount of decomposition has not been so great; hence recomposition is not going on so rapidly as it is in the portion where fell the image of the panes. So in the after image, the panes look dark and the sash light.

Young-Helmholtz Theory.—Another theory, known as the Young-Helmholtz theory, does not consider the recomposition of the substances as giving rise to a sensation at all. According to this theory, there are three substances—red, green and blue. The decomposition of any one of these substances by the light waves of the particular length that are alone capable of affecting it, gives rise to the appropriate sensation. The decomposition of all of them in the same degree gives rise to the sensation of white, and all other color sensations are produced by the decomposition of two or three of them in varying proportions.

How Explain Complementary Image.—In the complementary image, formed as in the experiment described, the red substance in that portion of the retina on which the image of the red spot fell, has been mostly decomposed; while the green substance in the same area has scarcely been affected by the red light. When we look at the white wall afterward, both red light and green light fall upon that same spot, but the red light finds little red substance to decompose, and the green light

finds much green substance. So there is a preponderance of the green sensation, with not enough of the red sensation to neutralize it and make it white.

Neither Theory Satisfactory.—Neither the Hering theory nor the Young-Helmholtz theory can be considered satisfactory, although they are probably the best we have. The Hering theory has been believed to be more nearly satisfactory than the other. Both of them are chemical theories.

Four Color Senses.—It seems that in order to establish a satisfactory theory of color vision, we must recognize the fact that there are at least four primary colors—red, green, blue and yellow. Each color depends upon the fact that a particular brain center is traversed by an impulse. There are in all probability at least four different brain centers for the color senses. An object appears to be of a particular color because the impulse that is set up in certain cones of the retina is transmitted to its appropriate center.

SIDELIGHTS

That a center for color vision distinct from the visual center exists in the cerebral cortex, is rendered probable by the occurrence of hemianopsia for colors, and also by the experiments of Haidenhain and Cohn on the influence of hypnotic trance upon color blindness.—*American Text Book, Volume II, p. 339.*

It is probable that children distinguish grades of light and shade rather minutely before the perception of colors is much developed.—*Hall's Adolescence, Volume II, p. 33.*

DEFINITIONS

White Light.—Ether vibrations of all frequencies from 392 trillion to 760 trillions per second.

White.—A sensation accompanying an impulse established by white light reflected in large amount from an object.

Black.—A sensation accompanying an impulse established by white light reflected in small qantities from an object.

Gray.—A sensation accompanying the impulse established by white reflected in quantities between the black and white.

Neutral Gray.—A gray that is neither dark nor light.

Brightness.—The quantity of the sensation of sight depending upon the amount of light that establishes the impulse.

Color Blindness.—The inability to distinguish color, while the ability to distinguish brightness is present.

After Image.—The appearance of an object after the eyes have been closed. It is accompanied by a retinal impulse.

Positive After Image.—That kind of an after image in which the relations of light and dark are the same as in the object perceived.

Negative After Image.—That kind of after image in which the relations of light and dark are reversed.

Complementary Image.—The image of a complementary color following the perception of a colored object.

Complementary Color.—A color which when mixed with another will produce white or gray. Each color is said to be complementary to the other.

CHAPTER VII

The Sensation of Hearing

Hearing.—The next most important sense after that of sight is the sense of hearing. We shall need to study first the structure of the hearing organ, by means of

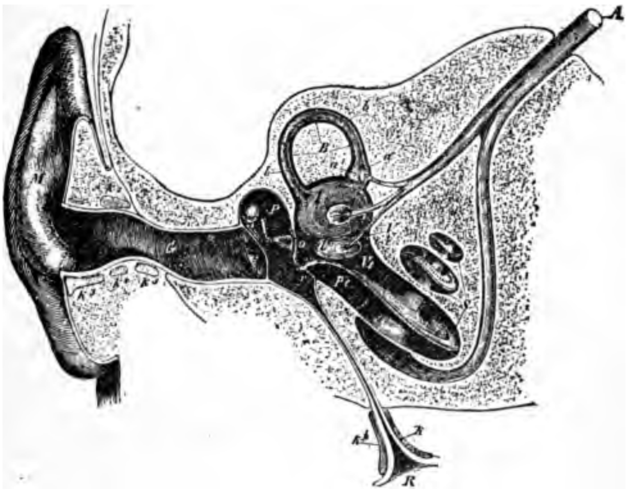


Fig. 17—Parts of the ear showing external, middle and internal ear; semicircular canals, cochlea, eustachian tube, vestibular and auditory nerves.

which the impulse is established; second, the nature of sound; and third, the sensation itself.

External Ear.—The ear may be considered as composed of three parts, the external, middle and internal ear. The external ear is called the pinna, or concha, and

is really of little use except as a support for ornaments. In some of the other animals this part is of considerable importance. Animals that pursue their prey, like cats and other carnivora, have the ear turned forward. Animals that flee from their enemies generally have the ear turned backward. Man combines both characters, which neutralize each other, and the position of his ear is not significant.

Muscular Adjustment of the Ear.—Some animals can adjust the position of the ear to the direction from which the sound comes. The muscle for the movement of the ears is found in all persons, but in nearly all it is vestigial, and in others it is only slightly functional. A few persons can move their ears slightly.

Auditory Meatus.—The other part of the external ear is the auditory canal, or the external auditory meatus. It is slightly bent, is about an inch long and terminates at the ear drum, or tympanic membrane.

Middle Ear.—The middle ear is bounded outwardly by the tympanic membrane, and on the other side by a bony partition that separates it from the internal ear. It is filled with air, and in order that the air may have the same pressure on the inside that exists on the outside, there is a narrow tube connecting the middle ear with the mouth. This is the eustachian tube, something over an inch long, opening into the back part of the mouth or throat, and so narrow that the air passes not very readily through it. When this tube is completely closed, the sense of hearing is likely to be dulled.

The Tympanic Membrane.—The tympanic membrane is a thin membrane, but it is not merely a drumhead. A drumhead will respond to vibrations of only one rate, while the tympanic membrane must respond to vibrations of all rates. Hence it is not merely a membrane

stretched over a cavity. It is convex toward the middle ear and concave toward the outer. Its shape on the concave surface is more or less parabolic, and it is this shape as well as the muscular tension to which it is subjected, that permits it to respond to vibration rates of all frequencies, within limits.

Damping of the Tympanic Membrane.—A drumhead will continue to vibrate until it is brought to rest by its own inertia and by the resistance of the air. Such a condition in the tympanic membrane would be fatal to good hearing. So the vibrations of the tympanic membrane are damped, or stopped, by the attachment of a chain of bones to its inner surface, when the vibrations of the air on the outside that have set it into motion have ceased.

The Ear Bones.—The vibrations of the tympanic membrane are transmitted across the middle ear by a chain of bones, attached to it on one side, and to a membrane that covers an opening through the bony wall of the internal ear on the other. The chain consists of three bones, called respectively the malleus, or hammer; the incus, or anvil; and the stapes, or stirrup. It is the malleus that is attached to the tympanum, and the stapes is attached to the membrane that closes the fenestra ovalis, or opening through the bony wall of the internal ear.

Functions of the Bones.—These three bones do something more than merely transmit the vibration. They damp the vibrations of the tympanic membrane, they transmit the vibrations, and they are attached to each other in such a way that they serve as multiplying levers, intensifying the vibrations that are transmitted to the membrane closing the fenestra ovalis. When these bones become anchylosed, or grown together, as they may in

case of inflammation of the middle ear following a bad cold, the hearing is much impaired.

The Inner Ear.—The inner ear is contained in a cavity hollowed out of a bone of the skull called the mastoid process. The rounded prominence just behind the external ear indicates its position. The entire cavity is filled with liquid, the endolymph, and it is reached from the outside through an opening, the fenestra ovalis, which is closed by a membrane to which the stapes is attached. A vibration of the stapes will set the liquid which fills the internal ear into vibration. If the walls

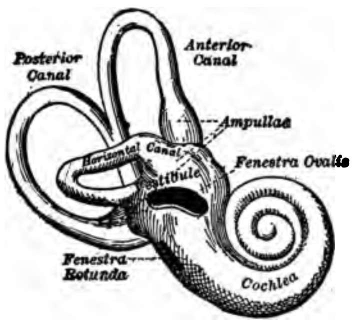


Fig. 18—The internal ear.

of the internal cavity were perfectly rigid, the liquid could not be thus set into vibration; but there is another opening, called the fenestra rotunda, covered by a flexible membrane, which permits the endolymph to vibrate.

Two Organs in the Internal Ear.—The internal ear really consists of two parts containing two different sense organs, and giving rise to two different sensations. The one sense organ is the semi-circular canals, and the other is the organ of hearing. The two parts are continuous with each other, the same liquid fills both, and the vibrations which affect one equally affect the other. But their

whole structures are different, and likewise are the sensations to which they give rise.

The Semi-Circular Canals.—The semi-circular canals are three in number, and are placed approximately at right angles to each other. The sense located in them is the sense of equilibrium by means of which we may know when we are falling, or turning round. It gives rise, too, to the sensation of dizziness. The fact that the three canals are placed at right angles to each other enables us to perceive our movement in every direction.

The Ampulla.—At the base of each semi-circular canal is a slight enlargement called the ampulla, and it is on the inside of the surface of this ampulla that the nerve fibers are distributed. These nerve fibers, which are extremely fine, project out into the liquid.

The Otoliths.—In this portion of the semi-circular canals, also, are to be found some very fine particles like sand grains, which, of course, are secretions, or concretions, produced in the ear, and called otoliths. When a movement of the body changes the position of the semi-circular canals, the liquid does not immediately take up the motion, and consequently the nerve fibers strike against the otoliths, or the vibrations so produced cause the otoliths to strike against the fibers, and the result is a nervous impulse, which is carried to the center of equilibrium in the brain. This kind of organ is called a shake organ, and is found in crawfishes and many other animals. It is not properly called an ear. The nerve of the semi-circular canals is a different nerve from the auditory nerve. It is called the vestibular nerve, although both auditory and vestibular nerves follow approximately the same path to the brain, and constitute elements of the eighth pair of cranial nerves.

The Cochlea.—The organ of hearing is located in that

part of the internal ear which is called the labyrinth, or cochlea. It is shaped a good deal like a snail shell and turns about two and a half times around an axis, called the columella. It is filled with endolymph, and lined with a membrane. About the middle of the cavity a bony shelf projects out from the columella, called the lamina spiralis. It follows the windings of the cochlea throughout its length. From its outer edge projects a membrane

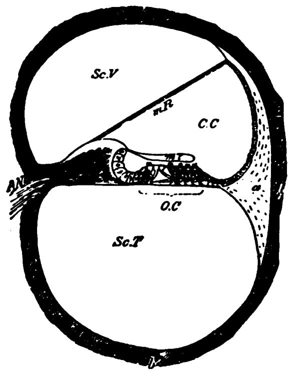


Fig. 19—Section of the cochlea showing its principal divisions and the organs located on the basilar membrane.

reaching to the sides of the cochlea along the outer wall. This is the basal, or basilar membrane.

Divisions of the Labyrinth.—From a point slightly back of the edge of the lamina spiralis and projecting rather upward and outward to the bony wall of the cochlea, extends a membrane called the membrane of Reissner. Thus the basal membrane and the membrane of Reissner divide the entire cavity of the bony cochlea into three cavities, parallel to each other and following its windings. The one below the basal membrane is called the scala tympani; the one above the membrane of Reiss-

ner is called the scala vestibuli; while the cavity between the membrane of Reissner and the basal membrane is called the membranous cochlea, and is the only one that concerns us, for it contains the organ of hearing.

The Organ of Corti.—The most characteristic organ supported upon the basal membrane is the organ of Corti, which consists of two parallel series of cartilaginous rods, leaning toward each other, and forming between and under them a triangular tunnel called the tunnel of Corti. In the outer series of rods there are about 4,500 and in the inner series about 6,000. The close approximation

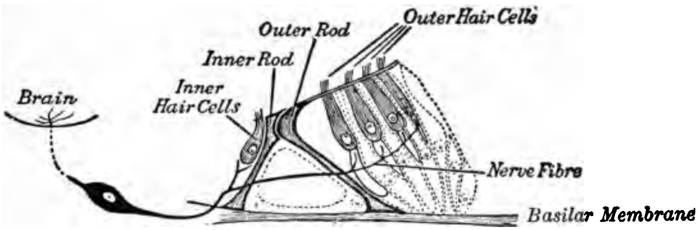


Fig. 20—Essential structures of the hearing organ located on the basilar membrane.

of the number of rods to the number of tones that the human ear can appreciate led the early investigators to believe that each rod of Corti corresponded in some way to a separate tone. It is now known that such can not be the function of the rods of Corti, and the present belief is that they serve to damp the vibrations of the basal membrane, much as the dampers on a piano damp the vibrations of the strings.

How an Auditory Impulse Is Started.—The auditory nerve is distributed along the basal membrane and cells terminating in nerve cells and bearing nerve hairs rise from its surface, extending into the endolymph. There are two series of these hair cells, an outer and an inner

series, ranged along the outer and inner sides of the organ of Corti. These nerve hairs of the outer series project up through openings in the reticulate membrane, which extends outward from the top of the organ of Corti. It seems probable that the basilar membrane is set into vibration by the movements of the endolymph transmitted from the tympanum, and this vibratory movement of the membrane is communicated to the nerve hairs connected with it. These vibrations of the hair cells being opposed by the liquid, and perhaps by the edges of the openings of the reticulate membrane, establish an impulse which is transmitted to the hearing center in the temporal lobe of the brain.

Basilar Membrane a Selective Organ.—It seems that the basilar membrane is the organ that sorts out the different vibrations, responding in one part to the high tones and in another to the low; but the high pitched tones seem to affect the widest part of the membrane, so that the problem is a complex one, and is as yet very imperfectly understood.

Number of Sound Vibrations.—Sound itself consists of vibrations in the air. These sound vibrations differ widely from those which affect the eye and produce the sensation of sight. The air is a much denser and coarser form of matter than is ether. The light waves are transverse, while the sound waves are longitudinal. The particles of air in a sound wave vibrate in the direction of the ray, not transversely across it. Light moves at the rate of 186,000 miles in a second, while sound moves at the rate of about 1,100 feet in a second. Instead of there being 392 trillion vibrations in a second as in light, the numbers of sound vibrations vary from 16 in a second to 76,000. In music, the extreme vibration rates are not employed. In an orchestra, the lowest and highest notes

correspond to vibration frequencies of 40 and 4,200 respectively.

Tone and Noise.—We may draw a distinction between a tone and a noise. A tone is produced by regularly recurring vibrations of the same kind; while a noise is produced by irregular vibrations of different kinds occurring at the same time.

An Octave.—One note is said to be the octave of another when it is produced by twice the number of vibrations. Two notes so related can easily be recognized as resembling each other in some way. The note which, on the piano, is designated as middle C has a vibration frequency of 256, although in concert pitch it is 261. The octave higher has a vibration frequency of 512. This is the tone C-I. The interval between C and C-I is divided into seven intervals which require eight notes for their determination, and from this fact the entire series is called an octave.

Relative Frequencies of Different Notes.—If we call the note C one of the scale, the other notes will have vibration frequencies represented by the fractions 9/8, 10/8, 4/3, 3/2, 5/3, 15/8, and 2 respectively. These fractions will correspond nearly to the vibration rates of 256, 288, 320, 340, 384, 425, 480, and 512. If we observe the ratio of difference between each note and its successor we shall see that the differences are 32, 32, 20, 44, 41, 55, and 32. The interval between 1 and 2 of the scale is called a whole step, or major second, and corresponds to a difference in vibration frequency of 32. The interval between 3 and 4 of the scale is called a half step, or minor second, and corresponds to a difference in vibration frequency of 20. The interval between 7 and 8 of the scale is also called a minor second, and corresponds to a difference in vibration frequency of 32, which is exactly the

numerical difference that corresponds to a major second between 1 and 2 of the scale.

Weber's Law.—This is as we should expect, or nearly so. To produce the octave of middle C we must add to its vibration rate 256. To produce the octave of C-1, we must add to its vibration rate 512. The psychological explanation of this phenomenon depends upon a principle that we shall discuss under the head of Weber's law. Briefly stated this is that in order to add equal amounts to the sensation, we shall need to add to the stimulus by increasingly larger amounts.

Pitch and Loudness.—Sounds differ in three respects: First in pitch, which corresponds to differences in vibration rates. Second in loudness, which depends upon amplitude of vibration. Amplitude means the difference in extreme positions of a single vibrating particle. It may be illustrated by stretching a string and then plucking it, causing it to vibrate. If the pluck, or stroke, be light, the middle of the string will not move very far from its rest position, and the sound will not be very loud. But if the pluck or stroke be stronger, the middle point on the string will be drawn much farther from its rest position, and the sound will be louder.

Timbre.—The third character of sound is its quality, or timbre. This is the character that enables us to distinguish a tone on the piano from a tone made by the human voice or a drum, or violin, even though it may have the same pitch and loudness.

Overtones.—The element of timbre depends upon the overtones. An overtone is an impulse established by the vibration of only a part of the vibrating body at the same time that the whole body is vibrating. A string may vibrate as a whole, but at the same time each half of the string may vibrate independently as a part, and each part

may be divided into smaller vibrating units, having independent rates of vibration. The excellence of tone in an instrument depends upon the number and harmony of the overtones.

Distinguishable Pitch Differences.—The ear that is sensitive and well trained can distinguish very small intervals of pitch. It is believed that in the part of the scale most easily covered by the human voice, from C-1 to C-3, in which the piano gives only 24 tones, the well trained ear can distinguish three thousand tones. This seems, however, like an extreme estimate, and much the larger number of persons do not have anything like that degree of sensitiveness. Many persons fail to discriminate intervals of less than a third of a major second, and some persons are unable to distinguish the interval of a minor second, or even of a major second. In extreme cases a person may be unable to distinguish a major third or even a major seventh. Such persons are tone deaf and may properly be said not to know one note from another. It is believed, however, that a well trained ear is able to distinguish eleven thousand tones.

SIDELIGHTS

Each sense, or sensation, enables us to recognize only one quality of the objects which have made an impression upon it.—*Morat, Physiology of the Nervous System, p. 652.*

It can hardly be doubted that the nervous structures of the cochlea form an organ of special sense for the perception of musical tones, and perhaps for noises as well. But no trustworthy conclusion can be maintained as to the precise mode of action of the auditory apparatus.—*American Text Book, Volume II, p. 380.*

The relation of the semicircular canals to equilibrium was first noticed by Flourens in 1824—De Cyon in 1874 was the first to speak of a sense of space, and connected with the more general conception of such a sense all the different experiments, including his own.—*Morat, p. 607.*

DEFINITIONS

Tympanic Membrane.—The drumhead, or the membrane that closes the tube of the external ear.

Cochlea.—The winding cavity of the internal ear in which is placed the organ of hearing.

Semicircular Canals.—Three almost circular cavities connected with the ear in which is located the sense of equilibrium.

Otolith.—One of the small particles in the semicircular canals whose agitation establishes an impulse in the endings of the vestibular nerve.

Organ of Corti.—An organ composed of two series of cartilaginous rods located on the basilar membrane.

Lamina Spiralis.—A bony shelf projecting from the columella.

Malleus, Incus, Stapes.—Names of the three bones of the middle ear.

Eustachian Tube.—The slender tube connecting the middle ear with the mouth.

Concha, Pinna.—The external ear.

Basilar Membrane.—A membrane attached to the edge of the lamina spiralis and supporting the hearing apparatus.

Sound.—Vibrations of the air between the limits of 16 and 76,000 a second.

Tone.—A sound consisting of regularly recurring vibrations.

Noise.—Irregular vibrations of different kinds produced at the same time.

Ampulla.—A slight enlargement at one end of each semicircular canal.

Endolymph.—The liquid contained in the internal ear.

Fenestra Ovalis.—The opening through the bony wall of the internal ear. It is closed by a membrane.

CHAPTER VIII

Other Sensations

The Five Senses.—It was formerly believed that there are only five senses: seeing, feeling, hearing, tasting and smelling. We have already discussed four: seeing, color, hearing and equilibrium. Each of these senses has a different end organ, different nerve, different stimulus, and

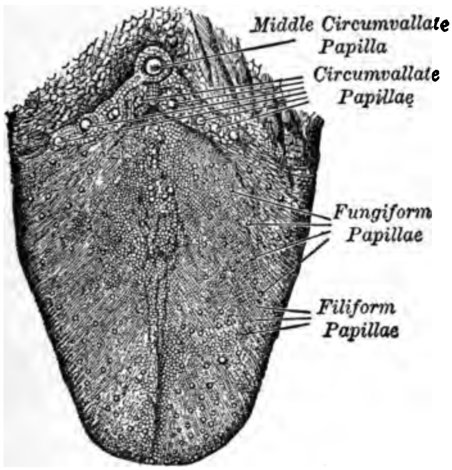


Fig. 21—Taste papillae of the tongue.

without any question, a different cerebral center. We shall see that there are many other senses.

Taste.—The sense of taste has for its end organ the termination of nerve filaments in the tongue. Upon the tongue are found various elevations containing nerve

endings, called papillae. These papillae are of various forms, the most conspicuous of which are the circumvallate papillae at the back of the tongue, which look like little craters, and are the places in which are disposed some flask-shaped bodies, the walls of which are composed of nerve cells constituting the termination of the taste nerves.

Taste Buds.—Other papillae are called fungiform, and are found along the sides of the tongue. Still others are

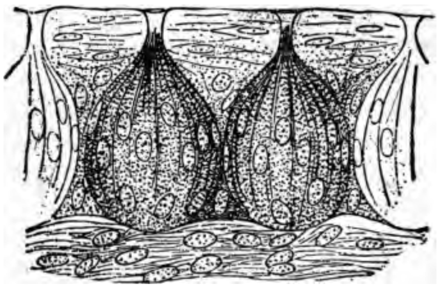


Fig. 22—Flask-shaped bodies, or taste buds.

filiform, or threadlike, and are found toward the tip. The nerve endings of these papillae are called taste buds.

Only Soluble Substances Tasted.—The essential character of the papillae is the same wherever found. The substance to be tasted must be of such a nature that it is capable of being dissolved. Marble and glass cannot be tasted because they will not dissolve. Sugar and salt will dissolve, and they can be tasted. We must not, however, make the mistake of asserting that anything which will dissolve can be tasted, for some soluble things are tasteless.

Substances in Solution Like Gases.—When a substance is in a state of solution, its molecules are separated

from each other, and it is in the condition represented by the molecules of a gas; so a substance that is in solution really manifests the properties of a gas.

Vibratory Movement of Gas Molecules.—The molecules of a gas are in a constant state of rapid vibration. Hydrogen is the lightest known gas, and its molecules vibrate at the most rapid rate. Under ordinary conditions of temperature and pressure, the molecules of hydrogen vibrate at a rate that carries them from three to seven miles in a second. Other gases with heavier molecules vibrate more slowly, but still rapidly enough to strike with their greater weight just as heavy a blow as a molecule of hydrogen. The weight of the molecule multiplied by its velocity must always be a constant quantity.

Pounding by Molecules Starts the Impulse.—The molecules of a salt when it is in solution have this same rapid vibratory movement; and it seems that it is this rapid pounding of the molecules of the dissolved substance against the nerve cells, or terminal filaments, that establishes the nervous impulse in the end organs of the nerves of taste.

Why Weak Solutions Cannot Be Tasted.—We can thus understand why a very weak solution of any substance cannot be tasted. Unless there is a sufficient number of molecules pounding the nerve terminations at the same time, the force is not sufficient to establish an impulse. It requires a sufficient number of blows per second, just as it requires a sufficient number of light waves per second, to establish an impulse.

Four Tastes.—Notwithstanding the number of different things that can be tasted, it is believed that we can experience only four different taste sensations: bitter, salt, sweet, and sour. Salt, in order to be tasted, must be placed in solution on the tip of the tongue, or it must be

dissolved in the saliva at that point. In whatever manner the tip of the tongue is excited so as to establish a nervous impulse, the resulting sensation is a salty taste. If the nervous impulse is started in the tip of the tongue by striking it with the finger, or with a glass rod, we shall experience the taste of salt. The tip of the tongue is innervated by a small nerve distinct from the gustatory nerve, which constitutes one of the branches of the facial nerve, and is known as the nerve of Wrisberg.

Where Located.—The bitter taste is experienced at the base of the tongue. If a bitter substance be placed at the tip of the tongue, it can scarcely be tasted at all. The base of the tongue is innervated by the gustatory nerve, which is a portion of the glosso-pharyngeal. The sweet and sour tastes are not so completely separated from the others, being located along the sides, and the sweet especially, being experienced at or very near the tip.

Taste Centers.—When a nervous impulse is established in a nerve of taste it is transmitted to some center in the lower portion of the temporal lobe. It can scarcely be doubted that there is a separate center in the temporal lobe for each of the four sensations, and consequently it would be perfectly proper to consider them as four distinct senses.

Smell.—The sense of smell is another one of the five senses originally distinguished. The end organ is in the nose. The two sides of the nose are separated by a bony partition called the septum, from each side of which project two curving bones, the upper and lower turbinate. The air that is breathed through the nose in an ordinary inspiration passes over the lower turbinate, and only slightly over the upper. This accounts for the fact that when we wish to smell a faint odor, we sniff, or make a

forced inspiration, thus forcing the air in greater quantity over the upper turbinate, where the smell nerves are distributed, and bringing the odorous particles into contact with the nerve endings.

Odoriferous Molecules.—The particles of the odorous body which affect the sense of smell must be in a state of molecular division in the air; and only those substances which are capable of sending off particles in this finely divided state can be perceived. We cannot smell iron or

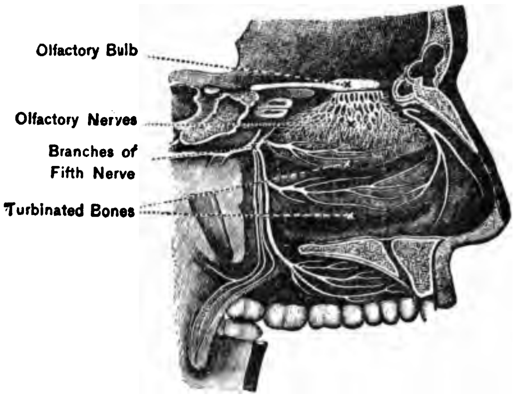


Fig. 23—Distribution of the olfactory fibers in the mucous membrane of the upper turbinate bone.

glass, because these substances do not evaporate, or send off molecules into the air in sufficient quantity to affect the nerve endings.

Olfactory Membrane Moist.—The mucous membrane which lines the nose is always moist, and if it should become dry the sense of smell could not be aroused. We may suppose that the molecular particles of the odorous body become dissolved in the moisture of the mucous membrane, when we have exactly the same conditions that prevail in the establishment of the taste impulse.

Similarity of Taste and Smell.—We thus see the close affinity that exists between the sense of taste and the sense of smell. The end organs are located very close together, both have their nerve endings terminating in the mucous membrane, which must always be moist before the sensation can be aroused, the particles that are tasted or smelled must be in a state of molecular division, and it is probable that it is the force of molecular vibration which establishes the nervous impulse in both. Both kinds of impulses are carried to the same lobe in the brain, and the brain centers are very close together.

Differences.—Although there are so many similarities between the senses of taste and smell, they are perfectly distinct. It is true that when the sense of smell is diminished the sense of taste seems to be diminished also in a very large measure, but this is probably on account of the fact that we sometimes mistake something that is smelled for something that is tasted. This may be accounted for by the fact that the odorous particles reach the olfactory nerve endings through the mouth and pharynx.

Modification of Taste by Smell.—But a more important consideration may be discovered in the fact that when two sensations are experienced together they modify each other; and in many cases the modification consists in the intensification of both. This principle will be discussed more fully in the following chapter, but it needs to be mentioned here, for it has never been sufficiently considered in the explanation of the fact that a decrease in the acuteness of smell diminishes the intensity of taste. A smell sensation, experienced at the same time with a sensation of taste, will intensify the taste.

How Many Smell Sensations.—We can smell a great many things, and it is a question how many sensations of smell we may distinguish. Some psychologists indicate nine different sensations, but the probability is that we have the rudiments of a great many more, all of them so slightly differentiated from each other that it is scarcely worth while to classify them. We might just as well say that we experience only one sensation of smell as to say that we experience forty.

Touch.—The fifth sense of the originally recognized five is the sense of touch. The nerve endings of the sense of touch are located in the skin, although they are not

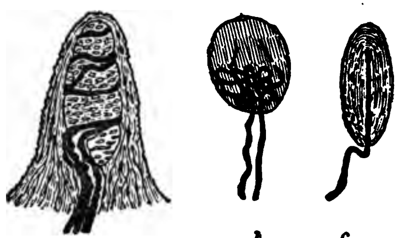


Fig. 24—Different kinds of touch corpuscles.

limited to it. They exist in the mucous membrane, the mesentery, and even in the ends of the bones. The most characteristic end organs of touch consist of a series of touch corpuscles of several distinct kinds, situated under the epidermis in the true skin. They are very small and so numerous that it is difficult to set the point of a pencil down anywhere on the skin without its coming into contact with one or more touch corpuscles. The contact of any foreign body with a touch corpuscle is sufficient to establish an impulse in the nerve ending, which is transmitted to the touch center in the brain.

How Measure Its Delicacy.—The sense of touch is more delicate in some parts of the skin than it is in others. Its sensitiveness is measured by the distance to which the points of a pair of dividers must be opened in order that they may be felt as two when both are placed on the skin. In this way it is found that the most sensitive place is the tip of the tongue, and next the tips of the fingers. The back of the neck is little sensitive, and still less so is the skin of the back. The points of the dividers must be placed at a distance of nearly two inches in order that they may be felt as two on the skin of the back.

Explanation of Difference in Delicacy.—The explanation of this phenomenon is not easy. It would seem as if the two points would be felt as two if each point rested on a different corpuscle, or if each rested within the circle of influence of the two corpuscles. But this would mean that when the two points were in the field of influence of the same corpuscle they would be felt as one. It would then frequently occur that the two points would be felt as two when they were close together and in different fields, while they would be felt as one when they were in the field of the same corpuscle but farther apart. If they were merely across the dividing line that separates the field of one corpuscle from that of another, they would be felt as two, even though the distance might be very small. There seems to be no evidence of such an arrangement. The distance that the dividers must be separated seems to be constant at any time in any given area.

Touch the Primitive Sense.—The sense of touch has for its brain center a cortical region just behind the motor area in the parietal lobe, and there seems to be some evidence that the two areas overlap. Touch gives us information of the roughness or smoothness of a sur-

face, and is best exercised by moving the surface over the skin, or the skin over the surface that is touched. It is the most widely diffused of any of the senses, and seems to be the general or primitive sense out of which the others have been developed, and of which they are merely the specialized manifestations.

Physical Contact Necessary.—We have seen that the object that is felt must come into contact with the touch corpuscles directly, or indirectly through the epidermis, before a nervous impulse can be established. Similarly the substance to be tasted must come into contact in a state of molecular division with the nerve endings of the sense of taste. The particles of the odorous substance in order to be smelled must come into contact with the nerve endings of the olfactory nerves. It is this mechanical impact of the particles in a state of molecular division that establishes an impulse in the end organs of taste and smell.

Physical Contact in Hearing.—In the same way the vibrating body must come into contact with the tympanic membrane through the medium of the air before its vibrations can establish an impulse of hearing. Thus the vibrating body is in indirect contact with the nerve endings through the medium of the air, the tympanic membrane, malleus, incus, stapes, the endolymph and the basal membrane.

Physical Contact in Seeing.—In like manner the eye comes into contact with the luminous body, or the illuminated body, through the medium of the ether, and the nervous impulse is established by means of the vibrations which the luminous body sends off. It might be demonstrated in the same way that the sense of equilibrium depends upon the direct contact of the otoliths with the nerve endings, although this sense differs from

the others in the fact that the information gained through it concerns the state of our bodies.

Every Sense a Modification of Touch.—So in a general way we may assert that in order to establish an impulse in any organ, the object that establishes the impulse must touch the organ, directly or indirectly, and exert upon it some mechanical force, of one kind or another. This makes every sense be a sense of modified touch.

Temperature.—A seventh sense is the sense of temperature. The end organs are nerve endings in the skin, and as a result of their location, the sense of temperature has for a long time been confounded with the sense of touch. We put our hand on a warm stove, and not only do we feel that it is smooth or rough, but we also feel that it is hot. But the immediate contact which is necessary for the sense of touch is not necessary for us to experience the sense of temperature. When we hold our hand near a hot stove, or a hot iron near our cheek, we experience the sensation of temperature without coming into immediate contact with the hot surface. Nor is it the contact of the heated air that is necessary to give rise to the sensation. We may experience the sensation of temperature when we hold our hand beneath a heated body, and in this case the air is rising from our hand to the heated body, rather than going from the heated body to our hand.

Heat Ether Waves.—The medium through which the temperature of the substance affects the endings of the temperature nerves is the ether. In this respect the temperature sense is more nearly like the sense of sight than it is like the sense of touch. The ether waves that establish the temperature impulse are longer than the light waves.

Hot Spots and Cold Spots.—In the skin we find spots which when irritated give us the sensation of heat, and other spots which give us the sensation of cold. We may call these the hot spots and the cold spots. The sensation may be aroused by exciting the spots on the skin by the fine point of a pencil, but the better way is to search for them with the fine point of a copper tube filled with hot or cold water. When we touch the hot spot with the hot point, we experience a sensation of heat. If we touch the cold spot with the heated point, we get no sensation. Similarly, the hot spot will give no sensation when touched with the cold point, or, the sensation will be exactly the same that it would be if the hot

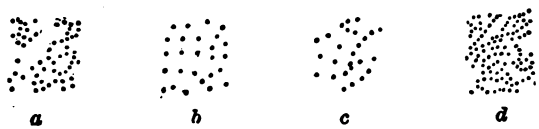


Fig. 25—Distribution of (a) heat spots; (b) cold spots; (c) small hairs; and (d) touch spots over the same small area of the skin, ten millimeters square.

spot were mechanically excited with the point of a pencil. When we stimulate a touch corpuscle with such a hot or cold point, we experience a sensation of touch only, not one of temperature.

Muscular Sense.—Another sense, which we may call the eighth, is the muscular sense, or the sense of resistance to muscular effort. When we hold a weight out at arm's length we experience a sensation whose impulse originates in the muscle. Whenever a muscle contracts it starts an impulse which is transmitted backward to the brain and accompanies the sensation of muscular resistance. It is the most delicate means we have for determining the weight of the body, and we may say that this

muscular sense gives us information of weight. Its end organ is in the muscle itself, and the brain center is undetermined, although it is probably in or near the motor area.

Pressure Sense.—Another sense is the pressure sense, which is distinct from the muscular sense. By it we may ascertain the weight of a body, but this means of estimating is not so delicate as is that of the muscular sense. We may illustrate the difference by placing a rather heavy body on the hand and holding it out at arm's length. When we are holding it in this manner, we are experiencing the sensation of muscular effort and that of pressure. Now if we let the hand with the weight upon it rest upon the table, we are no longer experiencing the muscular sensation, but the sense of pressure is experienced alone. It originates in the skin, and in the ends of bones, and no special end organs or brain centers are known for it. Sometimes the sense of touch is described as the sense of pressure.

Strain.—The tendons are organs by means of which the muscles are attached to the bones. When we exert the muscles so strongly that the tendon is injured, or its connection with the bone is threatened, we feel a soreness that arises from the injury to the tendon and we say that the tendon is strained. A strain is any sensation that arises from the tendon, and it does not need to be so intense as to constitute an injury. We know nothing about the brain center for strain, nor nerve endings, nor strain nerves.

Kinaesthetic Sensations.—The three sensations, muscular, pressure and strain, are all of them experienced when we hold a weight at arm's length. They are closely associated with movement of many kinds, and are so frequently experienced together that they are sometimes

classed under the same head as kinaesthetic, or movement sensations.

Hunger.—All the senses thus far studied have given us information of bodies outside of ourselves. But there are senses whose principal function is to give us information concerning the state of our own bodies. The first of these is the sensation of hunger, whose end organ is the stomach, and whose nerves are filaments from the sympathetic system. It gives us information concerning the condition of our bodies with respect to food and the need for the same. We know about this sensation and learn of the need for food by means of the connection which the sympathetic nerves have with the brain.

Thirst.—Almost the same thing may be said about thirst. This sense gives us information concerning the state of the body with reference to the condition of the fluids in it. A person who loses much blood experiences an intense thirst, and profuse perspiration quickly induces the same sensation. The end organ is located in the back part of the mouth and the top of the throat. Its nerve association is with the sympathetic system through whose connection with the brain we learn of the sensation.

Nausea.—The sense of nausea is located principally in the upper part of the esophagus. When the upper part of the esophagus, or back part of the throat, is irritated, we experience a sensation, and its reflex is a reversed action of the muscles of the stomach and esophagus. The usual direction of the contraction is from above downward. Under the influence of the sensation of nausea, the muscular contraction begins at the bottom, and proceeds upward. The nerve connection is with the sympathetic, and through that with the brain.

Number of Senses.—We have now enumerated thir-

teen senses, each of which arouses in us one or more sensations which are specifically distinct. We might greatly extend the number. Instead of one sense of color, it would in all probability be perfectly legitimate to distinguish four. Instead of one sense of taste, it is perfectly proper to call that sense four. Besides this, it is easy to extend the list to twenty-eight or twenty-nine distinct sensations, each in all probability having its own brain center and end organ. However, there seems little to be gained by trying to discriminate such a large number. It seems probable that there are in the human organism the beginnings or rudiments of many sensations and sense organs, but they are differentiated so slightly that there seems little to be gained in trying to define them. The old hierarchy of five senses, however, is no longer tenable.

Pain as a Sensation.—Many psychologists regard pain as a sensation, corresponding to sight, hearing and touch. This implies that there are separate end organs for pain, pain nerves, and a pain brain center. Also it implies that if the pain organs, nerves or brain centers were paralyzed, we should experience no pain of any kind.

The evidence for regarding pain as a sensation may be summed up under four heads: First, that a stimulus applied to certain parts of the body, such as the cornea of the eye, arouses the sensation of pain, but not the sensation of touch; second, that a stimulus applied to other parts of the body, such as the inside of the cheek, arouses the sensation of touch but not a sensation of pain, however great the stimulus may become; third, certain drugs, such as cocaine, destroy the sensation of pain temporarily, leaving the sensation of touch still functional; fourth, certain other drugs, such as saponin, paralyze the sensation of touch without affecting the sensation of pain.

Evidence Not Conclusive.—It appears that the evidence presented is not conclusive. Every one of the conclusions reached in the experiments may be explained more satisfactorily upon another supposition than that pain is a sensation. On the other hand, it is impossible to affirm conclusively that any pain organs have been demonstrated; second, there are no corresponding pleasure organs; and, third, there is no special stimulus for pain as there is for sight, hearing, temperature or touch. Pain may be experienced whenever the stimulus for any of the other senses acts upon the special organs for that sense in an excessive degree.

The Probable Truth in the Matter.—Many psychologists are very emphatic in regarding pain as a sensation. Titchener says: "That there is a sense of pain is a fact as well established as that there is a sense of pressure." (Feeling and Attention, p. 87.)

Mr. Titchener considers that pain, itching and stinging are different degrees of intensity of the pain sense, and paradoxically asserts that pain may not be painful, but may under certain circumstances be pleasurable.

The truth seems to be that experimenters have discovered in the skin other sensations than those of temperature and touch. There may be one, or several other senses located in the skin, not very sharply differentiated from each other. To one of these sensations the name pain has been applied, and we are asked to believe that all pain is associated with this new sense.

SIDELIGHTS

There is strong reason to believe that corresponding to the four primary taste sensations there are separate centers and nerve fibers, each of which when excited gives rise only to its appropriate taste sensation.—*American Text Book, Volume II, p. 412.*

We may suppose that for every area of peripheral distribution of tactile fibers in the skin there corresponds an area of tactile nerve cells in the brain. It can hardly be doubted that the nerve cells are divided into physiological groups characterized by inherent and inborn quality differences in the sensations aroused by their respective excitements.—*American Text Book, Volume II, p. 394.*

This perception (muscular sensation) may be the outcome of a direct consciousness of motor energy sent out from the motor cells, or it may be due to the inflow of sensory impulses which show the tension to which the muscles have been subjected. The latter view has more to be said in its favor.—*American Text Book, Volume II, p. 401.*

The heat spots are in their opinion (Blix and Goldscheider) locally distinct from the cold spots. No cold sensation can be produced in the former, no heat sensation in the latter. These observations are, however, not confirmed by Dessoir, and are theoretically so improbable that we may decline to accept them.—*Külpe, Psychology, p. 94.*

DEFINITIONS

Taste Papillae.—The end organs of the sense of taste.

Taste Buds.—The terminal nerve endings located in the papillae.

Turbinate Bone.—One of the two small curved projections of bone on each side of the septum of the nose.

Olfactory Nerves.—The nerves of smell.

Gustatory Nerves.—The nerves of taste.

Hot Spots.—The points in which are located the terminal filaments of nerves in which are established the impulses accompanying the sensation of heat.

Cold Spots.—Those in which are established the impulses accompanying the sensation of cold.

Kinaesthetic Sensations.—Those of the muscular, tendon and joint sensations. These are principally concerned in movement.

CHAPTER IX

Sensation

Psychology.—With our present chapter, we enter the domain of psychology proper. Heretofore we have been engaged so completely with the physiology of the subject that the psychological aspect has not been at all prominent. Now, however, it begins to take the leading place.

Sensation.—We have been studying the different senses and sense organs and much reference has been made to sensation. We have had much personal experience with sensations, and can best begin our study of them by undertaking to discriminate sensation from all other kinds of experiences, and to state what a sensation is.

A Mental Process.—A sensation is a mental process, and by this statement we distinguish it from a nervous impulse, which is a physiological process. The physiological, nervous impulse accompanies, and goes along with the mental process of sensation, but the two are clearly distinguishable. It is a convenient way to describe the sensation to say that it is the concomitant of the nervous impulse.

Sensation Simple.—But we need to discriminate a sensation from other mental processes, especially from those which are most nearly like it, such as the process that we call perception. The essential difference between sensation and perception is that sensation is a simple mental process, while perception is complex. A sensation in its

simplest, purest form is the concomitant of the transmission of a nervous impulse through a single brain center, while a perception is accompanied by the transmission of an impulse through several brain centers, and is a combination of several sensations. Hence we may say that a sensation is a simple mental process.

Sensation a Knowing Process.—But there are other simple mental processes that are not sensations. Some feelings are as simple as are sensations. We need to distinguish sensations from some of the simple feelings. Simple feelings are sometimes called affections, or simple affective processes, by which is meant any kind of process whose especial characteristic is pleasure or pain. It is not strictly correct to say that pleasure or pain is the affective process, but if we accept that as a tentative statement confessedly inaccurate, we shall be able to discriminate a sensation from it sufficiently to enable us to make a definition of sensation. A sensation is a process that makes us know, but does not make us feel. It makes us know the quality of an object. It is then a knowing process, an intellectual operation, and is thereby distinguished from a feeling process, or affection.

Qualities Correspond to Sensations.—I may look at a red book and experience the sensation red. So I may look at a red card, and half a dozen other red objects, and when looking at each one I experience a sensation similar to the sensation I experience when looking at any of the others. Hence I believe that there must be a similarity in the objects that corresponds to the similarity in my sensations.

Nature of the Correspondence.—But we need to ask what is the nature of that correspondence. The sensation red cannot be a picture, or an image of the quality. If we could examine the eyes, or the brain, with a

psychological microscope, we should not find anything in it to correspond in appearance and structure to the quality of the object. The sensation is not merely a projection of the quality upon the brain or upon the mind. The real nature of the correspondence we shall probably be forever unable to state. We may say that it corresponds, meaning by that that whenever we come into contact by means of any of our senses, with the object which manifests this particular quality, the sensation always ensues.

Definition of Sensation.—Our definition of sensation, then, is that it is a simple mental process that makes us acquainted with the quality of an object. This distinguishes it from an affective process, but it does not distinguish it from other intellectual processes such as idea, attention, memory and consciousness. We need to state some other characters of sensation that will distinguish it from these.

Physiological Concomitant.—The essential distinction between sensation and other intellectual processes can best be described in terms of the physiological concomitant. We call the process we are defining a sensation, and associate it with the senses and sense organs. A sensation always accompanies a nervous impulse that is established in a sense organ, or which originates upon the outside of the body.

Peripherally Initiated Impulse.—The outside of a sphere or a circle or other body, we designate as the periphery. So we may describe a nervous impulse that originates in a sense organ, on the outside, or periphery of the body, as a peripherally initiated impulse. When we sit down to think or remember, or reason, nervous impulses are traversing brain centers, but these impulses do not originate in sense organs, but in the brain centers

themselves. We may call such impulses centrally initiated, and they accompany all mental processes except sensation and perception, which alone are accompanied by peripherally initiated impulses. Inserting this distinction into our definition we may say that sensation is a simple mental process which makes us acquainted with a quality of an object, and which is the psychological concomitant of a peripherally initiated impulse.

Sensations Not Dependent Upon Sense Organs.—It is our purpose next to inquire how one sensation differs from another, and upon what does the difference in sensations depend. We have already considered the senses of sight, hearing, taste and others, and we have seen that each sense has its own kind of sense organ. We shall very naturally expect that the difference in sensations depends upon the difference in the end organ in which the impulses originate. This is the notion expressed by Külpe in the quotation at the beginning of this chapter, but it seems rather easy to demonstrate that such is not the case.

Illustration.—If the eye were removed from the head, a nervous impulse might still be established in the retina, but there would be no sensation of sight. If the nervous impulse were established in some other way than by the activity of the end organ, as has been done in some cases, we should still experience the proper sensation. We have all of us fallen down and bumped our heads, and have seen stars and constellations and a whole milky way; but the sensation did not come as the result of ether waves impinging upon the retina. A nervous impulse is established by the jarring of the brain center, or the optic nerve, or perhaps by the jarring of the retina. At least, it is not the proper and ordinary

action of the sense organ that sets up the impulse which accompanies the sensation of sight.

Centrally Initiated Sight Sensations.—If we press upon the eyeball with the finger, we experience the sensation of sight. If the optic nerve be pinched with a pair of forceps, we yet experience the sensation of sight. If we merely think, or try hard to remember how an object appeared when we once saw it, we can experience a sensation of sight, although it may be faint. However, some persons are able to project visually an image as vivid as a real object when seen. In such a case it appears evident that it is not the end organ which is concerned in the production of the impulse.

Function of a Sense Organ.—It appears that the end organ is merely a device by means of which a nervous impulse is established by its proper or specific kind of excitation. The eye is a device by which the extremely feeble ether waves are able to establish a nervous impulse. The ear is a device by which sound waves establish an impulse. The taste organs are devices by means of which the molecular solution establishes an impulse. So all that the sense organs do is to enable a nervous impulse to be established by different kinds of forces.

Sensation Not Determined by the Nerve.—It thus appears that we may eliminate the end organs from consideration, when we undertake to determine why one sensation differs from another. Is it then the nerve that determines what the sensation shall be? It was at one time supposed that the optic nerve would transmit only sight sensations; the auditory nerve auditory sensations only. It was believed that if it were possible to establish a sight impulse in the auditory nerve, that nerve would fail to transmit it. This is the doctrine of the specific energy of the nerves. We now know that any nerve will trans-

mit any kind of impulse in either direction. The nerve itself is neutral. Whatever impulse is established in it, no matter by what means, whether it be the activity of its proper sense organ, by mechanical stimulation, or by electric shock, will be transmitted.

Are Determined by Brain Center.—We are then thrown back upon the only other element in the arc, that is, the brain center. We have reason to believe that the sensation is what it is in consequence of the brain center through which the nervous impulse is conducted. We experience sight sensations, not primarily because we have eyes, but because impulses are transmitted through the sight centers in the occipital lobe. We experience sound sensations because impulses traverse the combinations of cells in the center for hearing. It makes no difference by what means or in what organs the impulses are established, if they go through the sight center, we experience the sensation of sight.

Eye and Ear Interchanged.—Occasionally we read in newspapers that some celebrated surgeon a long ways off, either as the result of a blunder or for the purpose of experiment, has misplaced the connection between the auditory and the optic nerve, so that the ear is connected with the proximal end of the optic nerve, and the eye with the proximal end of the auditory nerve. Then the patient sees with his ears and hears with his eyes. We need not concern ourselves with the possibility or impossibility of such an event ever occurring, for it would be about as reasonable to suppose that the same celebrated surgeon had misplaced the connection between a man's leg and his head, so that the leg, cut off at the knee, was made to grow on the stump of the neck, and the head was placed so that it grew where the knee was formerly attached. But we may merely assert that if anything ever

happened that way that is just the way it would happen. But if the auditory nerve were so connected that the impulses established in the ear were transmitted through the sight center, and the impulses established in the eye were carried to the hearing center, then we should see music and hear a picture.

Different Sensations From Same Sense Organ.—We have no difficulty in discriminating sensations as qualitatively different when they are the accompaniments of impulses established in different sense organs; but we may experience sensations qualitatively different when the concomitant impulses are established in the same sense organ. The sensation of sweet is qualitatively different from the sensation of bitter; and the sensation of red is different from the sensation of blue. The explanation must be the same. The combination of brain cells traversed by an impulse when we experience the sensation red, is a different combination from that which is traversed when we experience the sensation blue, although both combinations are found in the occipital lobe. Not only are the combinations different, but no single cell that is found in one combination occurs in the other. This is the final test by which we may judge whether one sensation is qualitatively distinct from another or not.

The Synaptic Process.—Our discussion of sensation will not be complete unless we go one step farther in locating the point at which the concomitant physiological process occurs. We have gradually narrowed the field of our investigations from the brain, through the cerebrum, hemispheres, cortex and neurons, and now it is possible to go one step farther and assert that the physiological change which accompanies a sensation, as well as every other mental process, occurs at the tips of the den-

drites, or just at the point where the nervous impulse passes from one neuron, or brain cell over to another. This point where the dendrite of one cell and the axon of another most nearly approximate each other is called the synapse, and the physiological concomitant of a mental process is a synaptic function. It is not a function of the cell, nor is it associated with cell structure; but it is a systematic function, a dynamic effect, and depends upon the transmission of the impulse from cell to cell. We see then how inaccurate are the expressions that assert that ideas are stored away in cells; or that the brain retains impressions, and many other expressions of a similar nature.

Quantitative Difference.—Besides the qualitative difference, sensations differ in another respect. They may be of the same kind, but differ in intensity. We may call this a quantitative difference and say that sensations are strong or weak. Adjectives are not merely qualitative, but qualifying adjectives may be compared. Qualifying adjectives express qualitative differences in sensations, but comparison of adjectives expresses a quantitative difference. Thus we have sweet, sweeter, sweetest; cold, colder, coldest; brave, braver, bravest.

Depends Upon Intensity of the Stimulus.—We need have no hesitation in saying that the intensity of the sensation depends upon the intensity of the stimulus; but it would be a wrong conclusion to infer that an increase in the stimulus would cause an equal or similar increase in the sensation. Doubling the stimulus does not double the intensity of the sensation.

Example of Light.—The determination of the law that governs the relation between the increase of stimulus and the increase in sensation is difficult. We may see to read in a faint light, but doubling the amount of light

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does not enable us to see to read twice as well. So it is a very gross exaggeration to say on a fine moonlight night that it is as light as day. It can be shown that if the entire sky were covered with full moons, each as bright as the one we see, and the amount of light increased 10,000 times, it would still be not even one-eighth as bright as day. But the ability to see by moonlight is much greater than one ten-thousandth, or one eighty-thousandth of what it is by day.

Example of Weight.—If I hold a weight of 100 grams in my hand, it will be necessary to add to this weight five grams before I can discover that there is any increase in sensation, or that the weight has become heavier. If I hold a weight of 20 grams in my hand, a weight of one gram added to it will be perceived as heavier. But if I hold a weight of 1,000 grams in my hand, an additional weight of neither one gram nor five grams will be perceived as making an increase in the intensity of the sensation. An additional weight of 50 grams must be placed with the 1,000 grams in order for the sensation to be appreciably increased.

Least Perceptible Difference.—This method of studying the increase in intensity of sensation is known as the method of least perceptible difference. It is not the absolute increase in the stimulus that produces equal increases in sensation, but the relative increase. In the illustration above, unequal amounts of stimulus produced equal amounts of sensation; but it will be observed in each case that the same proportion of weight was added to the amounts already supported. In this case, one gram, five grams and 50 grams increase in weight produced equal increase in sensation; but in each case the proportion of the weight that was added to the amount already supported was one-twentieth.

Threshold of Difference.—In the same way it has been determined that the intensity of light must be increased or decreased by one-hundredth of the amount before any difference in brightness, or intensity of sensation, can be perceived. The fraction representing the proportion by which the stimulus must be increased or decreased before any change in the intensity of the sensation can be perceived is called the threshold of difference. The threshold of difference for sight is one one-hundredth; for weight, one-twentieth; for strain, one-fortieth; for hearing, one-third; for taste or smell, about one-third.

Weber's Law.—The statement of the relation between the stimulus and the sensation is known as Weber's law. It may be stated in three different ways. First, in order that the sensation may increase by quantities always equal, the stimulus must increase by a constant fraction of itself. Second, in order that the sensation may increase in arithmetical progression, by the addition of a common difference, the stimulus must increase in geometrical progression, by a constant multiplier. Third, the sensation varies as the logarithm of the stimulus.

Explanation of Weber's Law.—The explanation of Weber's law is not easy, but the quotation from James at the conclusion of this chapter is very suggestive. If we adopt the view of the nature of the nervous impulse outlined in Chapter IV, we shall be helped much toward an understanding of it. Let us suppose that the transference of an equal number of atoms from one molecule to another is the concomitant of equal increases in sensation. But in order that there shall be equal increases in the number of atoms transferred, there must be a much greater force applied in establishing the impulse.

Illustration.—Let us suppose that there is a plum tree

approaching the time when the plums are ripening. If we give the tree a slight shake, some plums will fall. But in order to make an equal number of plums fall at the next shaking, we must increase the force applied. At the third shaking, the force must be tremendously increased if we wish to make an equal number of plums fall. This seems to be a fair illustration of what probably occurs in the establishing of an impulse.

SIDELIGHTS

Of all these phenomena, sensation is the most elementary. This is the original fact from which all others are derived by extensions, associations, dissociations or different combinations. In itself it is simpler than it appears to be. A sensation may be isolated from every other to such a degree as to leave no trace behind it.—*Morat, p. 650.*

If our feelings resulted from a condition of the nerve molecules which it grew ever more difficult for the stimulus to increase, our feelings would grow at a slower rate than the stimulus itself—Weber's law would thus be a sort of law of friction in the neural machine.—*James, Psychology, Volume I, p. 548.*

The latest and probably the most real hypothesis is that of Ebbinghaus, who supposes that the intensity of sensation depends upon the number of neural molecules which are disintegrated in the unit of time.—*James, Volume I, p. 548.*

I see no alternative but to affirm that the thing primarily known is not that a sensation has been experienced, but that there exists an outer object. Instead of admitting that the primordial and unquestionable knowledge is the existence of a sensation, I assert contrariwise that the existence of a sensation is an hypothesis that cannot be framed until external existence is known.—*Spencer, Psychology, Volume II, p. 369.*

We are pretty sure that a man, the inner end of whose optic nerve was in physiological continuity with the outer end of his auditory, and the inner end of his auditory with the outer end of his optic, might hear a picture and see a symphony.—*Martin, Human Body, p. 472.*

We are thus driven to conclude that our sensations primarily differ because different central nerve organs in the brain are concerned in their production.—*Martin, Human Body, p. 471.*

We are therefore justified in supposing that the nerve fibers and their central terminations are indifferent structures, physiologically capable of the most diverse functions, and that their specific character is imposed upon them from without. In other words, the excitations of the central organs are functions not intrinsically localized, but altogether dependent upon internal and external stimulation.—*Külpe, Psychology, p. 84.*

DEFINITIONS

Sensation.—A simple mental process that makes us acquainted with a quality of an object and which is accompanied by a peripherally initiated impulse.

Quality.—That in an object which corresponds to a sensation.

Peripherally Initiated Impulse.—One which starts in a sense organ.

Centrally Initiated Impulse.—One which originates in a brain center.

Qualitative Difference.—A difference in kind. One which is indicated by a different name.

Quantitative Difference.—A difference in intensity, not in kind.

Qualifying Adjective.—The name of a sensation.

Weber's Law.—A statement of the relation between an increase in the intensity of the sensation and the quantity of stimulus.

Threshold of Difference.—The fraction by which the stimulus must be increased before an increase in intensity of sensation can be perceived.

Synapse.—The point of nearest approach of two neurons, and at which the transfer of the nervous impulse from one brain cell to another occurs.

CHAPTER X

Perception

Perception.—Sensation is a simple, while perception is a complex, mental process. In other respects they are much alike, and as would be supposed, the two processes shade into each other. Let us study the process of perception as it is exemplified in the perception of an apple.

Exemplified in An Apple.—When I hold an apple in my hand and look at it, I experience several sensations. I experience a sensation of red, which informs me of one quality of the apple. I experience a sensation of green, since the apple is not red throughout its entire surface. I experience another sensation through the sense of sight, by means of which I judge of its size, and another sensation, also through the sense of sight, by means of which I judge its distance; and still another from which I judge its shape. I experience a sensation through the skin that informs me of its smoothness, and another that tells me it is cold. Still another sensation is obtained through the muscular sense which informs me of its weight, and possibly the sensation of strain and pressure enter into the same judgment.

Vivid Sensations Combine.—An enumeration of the sensations already indicated as experienced shows that we have appreciated at least eight, each of which is accompanied by a peripherally initiated impulse, and which in consequence of that fact we may call vivid sensations. They are all experienced at the same time, and they run together and modify each other. The resulting

combination of all the sensations, as they modify each other, constitutes the percept.

Pure Percept.—If these sensations already described were the only sensations that entered into it, we should have a pure percept. We might define a pure percept, then, as the sum of all the vivid sensations that we get from an object, as they combine and modify each other.

But a pure percept is seldom or never experienced. It is one of those philosophical abstractions, convenient to contemplate as the basis of theoretical discussion, but never realized in practice, unless it be in the very first perceptions that we ever experience.

Faint Sensations.—As soon as we have begun to experience the vivid sensations from an apple, through the senses of sight, touch, temperature and pressure, other sensations begin to appear. We begin to experience a sensation of taste, and perhaps our mouth begins to water. We experience a sensation of sour or sweet; we experience a sensation from which we judge that the apple is mellow, also that it is white inside, is juicy, and has a core and seeds.

Their Origin.—These sensations are derived from previous experience with apples. They are reproduced sensations, accompanied by centrally initiated impulses, and are consequently of that kind that we may call faint. It would really be better if we had some other word than sensation to apply to them, but as we have none, we shall continue to distinguish faint sensations from vivid; the difference being that vivid sensations are accompanied by peripherally initiated impulses, while the faint sensations are accompanied by centrally initiated.

Definition of a Percept.—All the sensations, both faint and vivid, run together, modify each other, and the resulting experience is called a simple percept. It is the

kind of percept we mean when we use the term without any modifying word. We may define a simple percept, then, as the sum of all the sensations, both faint and vivid, that we get from an object, as they modify each other.

What We Perceive.—We have described the sensation as a process that makes us know the quality of an object, and the percept contains no elements except sensations. It would appear, then, that the only thing that we can know about an object is the sum of its qualities, or such qualities of the object as our sensations are able to acquaint us with. Is there anything in the constitution of an object except its qualities? Are we compelled to define an object as the sum of its qualities, and fail to discover that there is anything else in the constitution of an object except qualities?

Idealism.—It is only a step from this position to the demonstration that there is no object nor external world. If we know only qualities, and know them only as they are correspondences to sensations, then we know really only sensations. The object, then, is only the collection of correspondences, and the only thing that we can be sure about is the mental experiences that we call our sensations. Hence if there were no sensations, and no mental processes, and no person to experience them, there would be no correspondence and no object and no external world. The world external to ourselves is merely a construct of our minds.

Transfigured Realism.—Persons who hold such opinions as are expressed in the preceding paragraph are called idealists. Persons who believe that the object is some real thing other than the sum of its qualities, and that we know the qualities by means of our sensations, are called realists. Herbert Spencer argued

that while we could know nothing about an object except its qualities, nevertheless the fact that there were qualities that we could perceive implied that there must be a thing in itself to which the qualities belonged. He argued that there must be a substantial thing in itself to serve as a substratum for the quality, since a quality could not exist alone. A quality without a substantial substratum would be like the smile of the Cheshire cat, in Alice in Wonderland. The Cheshire cat was sitting on the branch of a tree, smiling as all well regulated Cheshire cats do, when the tree and the branch and the cat gradually faded away, leaving only the smile out in space. What would the smile of a cat look like without the cat behind it?

Hence, Herbert Spencer asserted that the existence of a quality which we could know implied positively the existence of a real thing which we could not know. He called this the doctrine of Transfigured Realism.

Percept Not the Arithmetical Sum.—But the percept is not merely the arithmetical sum of the sensations that we derive from an object. It is the sum of the sensations as they modify each other.

Sensations Modify Each Other.—This modification of sensations by each other when they are experienced together is one of the most important principles in the understanding of the process of perception. We have already had occasion to refer to the fact in our discussion of the relations between taste and smell on page 82. That two or more sensations experienced at the same time modify each other is shown in many ways. The phenomenon of contrast represents it very well. Black always looks blacker when it is experienced in contrast with white. Red is redder when it is shown on a background of green. Sweet and sour emphasize each other.

Example of Lemonade.—Lemonade is made by mixing together lemon juice, which produces the sensation of sour; sugar, which gives us the sweet taste; a few drops of lemon oil, which is bitter; ice, which arouses the sensation of cold; water, which gives a touch sensation, and occasionally a pink color, which appeals to the eye. But none of these ingredients arouses the lemonade taste, or gives us the lemonade sensation. In fact, in lemonade, and better, in some other mixtures, it is very difficult, or almost impossible, to analyze out of the compound the sensational elements of which it is composed.

If the sensations that enter into the composition of the lemonade taste were to be experienced at different times, they would certainly not produce the lemonade taste. But even if the several ingredients were tasted at the same time in different portions of the mouth, the resulting percept would not be the same as if the ingredients were more intimately blended.

Of Contrasting Colors.—Red, yellow and green are all of them beautiful colors; but if combined conspicuously in a lady's dress, we say that the colors fight; they modify each other in an unpleasant manner. Salt is not in itself a very pleasant taste, but there is no other article of table use that appears in so many different articles of food. The little boy's definition of salt as that which makes potatoes taste bad when you do not put any on, emphasizes its function. Salt is especially powerful in modifying sensations of taste in such a manner as to intensify them.

Of Food.—We like to eat our dinner where the dishes and linen are clean. Dirty dishes and dirty table linen modify the taste of the food in an unpleasant manner. So beautiful tableware, china and silver contribute much

to the enjoyment of eating dinner. Music intensifies the pleasant taste of food.

Law of the Attraction of the Impulse.—The physiological concomitant of the modification of one sensation by another seems to be found in the fact that when two nervous impulses are established at the same time, they tend to run together and modify each other. The two or more impulses may run together in such a manner that the single impulse resulting is stronger than either of the two of which it is composed, or they may combine in such a way that they tend to diminish or nullify each other. In the one case, the accompanying sensations are intensified, while in the other they are diminished. The fact that two impulses established at the same time tend to combine is called by Mr. McDougall the Law of the Attraction of the Impulse.

Completed Definition.—The percept, then, is the sum of all the sensations, both faint and vivid, that we receive from an object, as they modify each other. Since the sensations are experienced at the same time they are held together by that form of association that is called simultaneous association. Here it may be well to consider another phenomenon of sensation and perception, which tends to verify the accuracy of the interpretation here laid down, and which at the same time may be explained by it. This is the phenomenon of colored audition, or colored hearing, or chromoaesthesia.

Colored Audition.—Some persons experience a sensation of color when they hear certain letters, or words. Each word or letter seems to have its own color, but the color is not necessarily the same for any two persons. Dr. David Starr Jordan asserts that the different letters of the alphabet have for him different color values, so that he always experiences the different color sensations

whenever he hears the sounds of the letters. X, Z, F, E, H, A, N are always red. L, T, B, R are green. O is yellow. Names of persons, days of the week and months of the year have different color values for different persons. In a very few instances, other sensations than color and hearing are associated. In one case a distinct sensation of temperature was associated with the sound of words, and in another that has been reported color was experienced in connection with different tastes.

How Account for It?—We may suppose in case of colored hearing that when the letter O, for example, in President Jordan's case, is heard, the nervous impulse established in the hearing center is transmitted over into the color center, and passes through the combination of cells that is associated with the color sensation. This pathway between the hearing and the color center has probably been rendered easy of access in consequence of early association. In President Jordan's case, the letters may have been learned originally from colored blocks, and the two centers for sight and hearing became thoroughly associated in that way.

Its Bearing Upon the Theory of Perception.—The significance of the phenomenon of colored hearing for the theory of perception depends upon the fact that it shows that different brain centers are traversed by the same nervous impulse, and by inference, that different sensations are associated in the perceptive process.

What a Brain Center Is.—We are now ready to understand that there must be much modification of our original theory of the localization of function. We defined a brain center in such a way that it would be supposed to consist of a number of brain cells in close proximity to each other. But in the perception of an apple, we have reason to believe that many different brain cen-

ters, in several regions of the brain, come to be associated and are traversed by the same nervous impulse. These several combinations of brain cells in different sensation areas may be widely separated; but since they are traversed by the same nervous impulse, they constitute in effect a single brain center. Hence, we shall need to define a brain center as a combination of cells traversed by the same nervous impulse. It is the impulse itself that defines and delimits the brain center, and not mere geographical proximity. This adds enormously to the difficulty of making a thoroughly satisfactory demonstration of the truth of the doctrine of localization of function.

Assimilation and Apperception.—As soon as we have obtained a simple percept of an apple, other ideas begin to rise up in the mind. We no sooner think of the apple than there begin to appear other related ideas: tree, orchard, cider, apple pie, Garden of Eden, worm, scale insects, seedlings, grafts and many other ideas, depending for their number and particular kinds upon our previous experience. These related ideas associate themselves with our simple percept, and the result is what we may call an assimilation. The process by which an assimilation is formed we may call apperception. An assimilation, then, is the sum of the simple percept together with all of its related ideas. It may be well to notice that the word apperception, as here used, has a somewhat different signification from the Herbartian sense of the word, and indeed is different from the use that is made of it by Wundt.

Distinguishing Characteristic of a Percept.—A percept must always involve some sensations that are accompanied by peripherally initiated impulses. That is, in every percept there must be some vivid sensations. In

nearly every case, at least, there are also faint sensations, but the vivid sensations must occur if we are to call the resulting process a percept.

An Idea.—When we experience a process in which all the sensations are faint, accompanied by only centrally initiated impulses, the process is not a percept but an idea. An idea may be defined as a remembered percept, or a percept without vivid sensations, or a process in which faint sensations only are combined.

Idea and Faint Sensation.—It is better to reserve the word idea for this use than to employ it as some psychologists do, to express a faint sensation. It would conduce to clearness if we had some other word than sensation to express the notion of a simple mental process that is accompanied by a centrally initiated impulse only. But as it is, we have no such word, so we may discriminate faint and vivid sensations by means of their accompanying centrally and peripherally initiated impulses.

Difference Between Idea and Percept.—A percept differs from an idea primarily in its vividness. The percept is vivid, the idea is faint. If an idea were to become as vivid as a percept, we should then experience an hallucination. The percept is accompanied by some peripherally initiated impulses, the idea by no peripherally initiated impulses. A percept is usually more accurate than an idea, largely in consequence of its greater vividness.

Association Centers.—In this explanation of the difference between a percept and an idea, it has been assumed that both centrally initiated and peripherally initiated impulses traverse the same combination of brain cells in the percept and idea of the same thing, and that this combination includes cells in both cases that belong to different sensation centers. Those who hold

positively to the doctrine announced by Flechsig concerning his association centers, will postulate another difference between idea and percept. They will assert that in a percept the impulses traverse sensation centers, but that in an idea, impulses traverse association centers only, none passing through the cells in the sense areas. It seems very unlikely that such an hypothesis can be substantiated, and the weight of the evidence is strongly against such a notion.

SIDELIGHTS

The task of the psychologist is to reduce every mental process to a neural process; every conception to perceptions, grouped and abstracted, as perceptions are sensations grouped and abstracted.—*Lewes, Problems of Life and Mind, First Series, Volume II, p. 199.*

Perception seems to involve in every case a synthesis of sensations and images of different senses, and the synthesis results in an establishment of relations of some kind among the sensations.—*McDougall, Physiological Psychology, p. 94.*

A perception is a group of elemental, irreducible, conscious processes called sensations.—*Bagley, Educational Values, p. 28.*

Two nerve centers stimulated at the same time secure a connecting path of least resistance by which, in future, the stimulation of the one overflows into the other.—*Münsterberg, Psychology and the Teacher, p. 142.*

It has been assumed that when two groups of cells, the substratum of two images, are excited at the same time, the nervous wave circulates from one group to the other through those communicating fibers which are so numerous in the brain.—*Binet, Psychology of Reasoning, p. 185.*

This might be called, for reasons that we shall consider presently, the law of the Attraction of the Impulse.—*McDougall, Physiological Psychology, p. 126.*

Ideas in their simplest form are reproduced, or recalled sensations.—*Höffding, Psychology, p. 141.*

We seem to be justified in calling the elements of both memory image and perception, sensations.—*Pillsbury, Attention, p. 95.*

DEFINITIONS

Percept.—The sum of all the sensations, both faint and vivid, that we get from an object as they modify each other.

Pure Percept.—The sum of the vivid sensations only that we get from an object.

Perception.—The process by which a percept is formed.

Assimilation.—The sum of the simple percept, together with all the related ideas.

Apperception.—The process by which an assimilation is formed.

Simple Percept.—See percept.

Idea.—The sum of faint sensations only. A remembered or reproduced percept.

Chromoaesthesia.—Colored hearing—colored audition. A phenomenon in which sensations of color are aroused by auditory sensations.

Transfigured Realism.—The doctrine that there is a real object to which the qualities belong, although we are able to know only the qualities and not the thing in itself.

Law of the Attraction of the Impulse.—A statement of the fact that when two impulses are established at the same time they tend to run together and constitute a single impulse.

Brain Center.—A combination of brain cells traversed by the same impulse.

CHAPTER XI

Hallucinations and Illusions

Hallucination.—Hallucinations and illusions are both of them errors in perception, and no discussion of the perceptive process can be satisfactory that does not indicate how the theory of perception may explain them. We have seen that a sensation is the concomitant of a peripherally initiated impulse. A percept is the sum of sensations, some of which are accompanied by peripherally initiated impulses. An idea is a somewhat similar process, except that the sensations that enter into it are all faint and accompanied by centrally initiated impulses only. The peripherally initiated impulse is always stronger than the centrally initiated, and the accompanying sensations are more vivid. It is by means of the vividness of the processes that we are able to distinguish a percept from an idea. When, however, it happens, as it sometimes does, that the centrally initiated impulse becomes unusually strong,—as strong as a peripherally initiated impulse would be under the same circumstances,—we are unable to distinguish the centrally initiated impulse and its accompanying idea, from a peripherally initiated impulse and its accompanying percept. When we lose this characteristic vividness of distinction we experience an hallucination. An hallucination, then, is an idea so vivid that we mistake it for a percept.

Occur When Vivid Percepts Impossible.—Hallucinations usually occur when the conditions for perception

are not very good. We are more likely to see ghosts in the dark, or dim light. The usual explanation of this fact is that the material of the ghost's body is so extremely tenuous that it is unable to withstand the disintegrating action of light. While this explanation would perhaps not be very satisfactory except to an extremely credulous ghost seer, it does illustrate the fact that hallucinations are likely to occur when the conditions for perception are somewhat unfavorable. Obscurity engenders all kinds of mistakes.

And When Attention Is Weak.—Still another condition favorable for hallucinations is that in which the attention is wandering. Hallucinations are sometimes experienced just when we are going to sleep, or just waking up, or in a condition of day dreaming, or revery. It is a condition in which a percept would not likely be very vivid, while the idea is likely to become so. The person who reports an hallucination frequently emphasizes the fact that he was perfectly placid, not in the least excited, and adduces this condition as evidence that he is not likely to be mistaken in his perception and that the appearance was not hallucinatory. This placid condition is one that is quite necessary for the most common type of hallucination.

Not Uncommon.—Hallucinations are not at all uncommon. A census of hallucinations shows that about one person in ten has at some time in his life experienced a true hallucination. The actual number is probably much greater than this, in consequence of the tendency to be forgotten, as well as the disinclination of many persons to report such an experience. The probability is very great that every person has experienced one or more hallucinations, but in much the larger number of cases they have not been recognized as hallucinatory.

Most Frequent in Young Persons.—The investigations into hallucinations indicate that the largest number occur to persons between the ages of 20 and 25 and the number diminishes as the persons become older. The probability is strong, however, that the younger the persons are, the greater the number of hallucinations they experience. In all probability, little children experience a large number of hallucinations, but they are not recognized by the children nor by their older associates as hallucinatory, and children have no way of describing their experiences of this nature, even if they were recognized. The intensity of nervous energy, such as little children manifest, is one of the contributory conditions of hallucinations.

Children's Lies.—Some of the lies that children tell may be accounted for by supposing that the children experience ideas so vivid that they are unable to distinguish them from a percept, and report as seen or heard or done things that were not seen or heard or done.

Hallucinations of the Dead.—Hallucinations frequently take the form of a vision of some one with whom the person is acquainted, but who has recently died or who dies soon afterward, or who is sick and in danger of death. Consequently it has been supposed that there is a very intimate connection, not to say prophetic relation, between appearances of an hallucinatory character and the fact of death.

Naturally Accounted For.—When hallucinations associated with the fact of death occur, we may account for them in a very natural manner. First, the visual appearance of a person who is dead is more likely to be recognized as hallucinatory than an appearance of any other character. Hence it is more likely to be reported in a census of hallucinations than is any other kind.

Better Remembered.—Second, such an hallucination, from the fact of its being associated with the death of a person, is likely to be remembered better than one in which no such connection can be traced, and is on this account more likely to be reported. The ordinary hallucination, like a dream, is very likely to be forgotten, or remembered with difficulty. This in itself implies a nervous impulse of little strength, and the vividness is more apparent than real.

Other Reasons.—Third, the person who has recently died or who is sick and in danger of death, is more likely to be in the unconscious thoughts of a percipient than another person who is in no such immediate danger of dying. Fourth, there is not much similarity between the hallucinations of the dead and dying, so that no relations between the forms that the hallucinations take can be traced. This in itself is sufficient to show that there is no real connection between hallucinations of this character and the fact of death. Fifth, a few such coincidences are nearly sure to occur according to the law of probabilities. Many more hallucinations, however, occur that are not connected in any way with the death of the person perceived than are so connected.

Historical Visions Hallucinations.—The probability is that all accounts in history of visions and angels and warnings and foreshadowings of death, and other mysterious appearances, when not intentional deceptions, are to be explained on the principle of hallucinations. Such will be found to be the explanation of the familiar demon of Socrates, who gave him warnings; of Joan of Arc, with her voices; of Mohammed, and the thousands of appearances of angels and devils to saints and ascetics.

Mostly of Sight and Hearing.—Hallucinations occur most frequently in the senses of sight and hearing, but

they may occur in any sense. Hallucinations of touch are not uncommon, while hallucinations of taste and smell have been experienced. A person who is subject to hallucinations is likely to become a veritable mine of ghost stories, while the real explanation is a very simple one.

Hallucinations of the Insane.—Insane persons are especially subject to hallucinations, if the insanity is of that kind which runs into maniacal forms, characterized by ravings and violence and much inflammation of brain tissue. A man in delirium tremens experiences the most prodigious forms of hallucinations. If, however, the insanity takes the form of melancholia, associated with a degeneration of brain tissue, and the loss of ability to generate nervous energy in the usual amount, hallucinations are seldom or never experienced. Frequently the hallucination is one of the first symptoms of oncoming insanity, although many persons experience hallucinations who can not be suspected of insanity in any degree. Whenever the centrally initiated impulses come to have an exaggerated intensity, which may or may not arise from a diseased condition of the brain, the result is a vividness of ideas that constitutes an hallucination.

Illusions.—But we frequently experience errors in perception that are not hallucinations. It is probable that every one of us has sometime gone down the street in the semi-darkness of the evening and has seen a friend standing at the side of the walk. As we approached ready to speak to him we discovered that instead of its being our friend it was a gatepost. Our friend may have been just as wooden headed as the gatepost, but that was not the point of resemblance which induced the mistake. Or we may have gone into our room when it was poorly

lighted and found some one sitting in a chair, who, upon investigation, proved to be merely a cloak or shawl thrown over the chair, and not a person.

Explanation.—Such experiences are illusions, not hallucinations. There is something there to see. A peripherally initiated impulse is established, but it is carried to the wrong center. The peripherally initiated impulse established by the gatepost went to the friend center instead of the gatepost center.

Miscalling Words.—The same explanation enables us to understand why we miscall words, or read them wrong. A child in the reading class called the word irrecoverable, irrevocable. The impulse that was established by the sight of the word went to the wrong center, and traversed the wrong combination of cells.

Two Sources of Error.—There are two explanations for illusions of this kind, or two sources of error. The first is that the nervous impulse is directed by a process of attention, and if we attend in the proper way, we shall direct the nervous impulse into almost any brain center that we wish. This is sometimes stated by saying that we see what we expect to see. Expectation is merely another name for a process of attention in a case like this, and is a very prolific source of illusion. If our attention is very perfect, we shall be able to see almost anything.

Hypnotic Illusions.—We shall find that the most satisfactory explanation of the phemonena of hypnotism is one that depends upon the fact that the hypnotic state is that of almost perfect attention. One of the most striking phenomena of hypnotism is that in which the hypnotized subject is induced to see almost any object that is suggested to him, in any place. This is an illusion depending upon the process of attention.

Illusions from Habit.—The other explanation is one in which the impulse is directed into the pathway established by habit. We see the thing that we are accustomed to see, and fail to see the new and unusual. The effect of the transmission of a nervous impulse through a nervous arc is to diminish the resistance the impulse encounters, for every transmission. The statement of this fact is called the law of neural habit.

The Law of Neural Habit.—The law of neural habit is such an important principle in psychology, and underlies the explanation of so many psychological phenomena, that we need to get a clear understanding of it. No fact in physiological psychology is better known or more fully recognized than that whenever a nervous impulse traverses a nervous arc, it modifies the arc in such a manner that the next impulse of the same degree of intensity will encounter less resistance. As the result of repetition, the arc ultimately furnishes so little resistance to the impulse that practically none of it is lost in transmission.

Inaccurate Expressions.—This principle is the only valid interpretation of the phenomena that are sometimes inaccurately described by saying that every mental action leaves some trace in the mind; that the mind retains a trace of every impression made on it; that ideas are stored up in the mind; and others of that nature.

Importance of the Law of Neural Habit.—It is the law of neural habit that lies at the basis of every explanation of mental or physical habit, and the economy of effort that arises from it. Also, we shall find that this law of neural habit explains the decrease of feeling in habitual experiences, lies at the foundation of the development of unconscious voluntary action, controls the growth of secondary passive attention, and is the source of many common forms of illusion.

A Third Principle.—These two principles are sufficient to explain almost every illusion that we experience. However, it may be profitable to postulate a third principle. If we have two lines of equal length terminating in forks, but the forks of one of them extending away

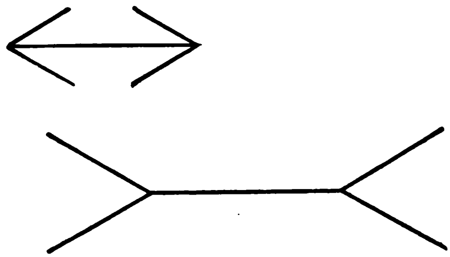

Fig. 26—Two lines of equal length that do not appear to be so.

from the middle of the line, while the forks of the other extend back toward the middle, the first line will appear the longer. This is an illustration of a very numerous

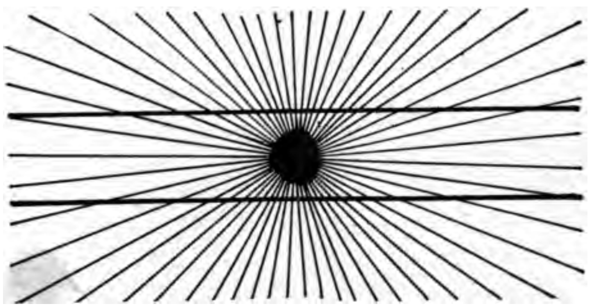

Fig. 27—Illusion of the curved lines.

class of illusions, the error in perception seeming to arise from the influence or effect of surrounding circumstances. Although this may be classed as an independent principle, it is capable of reduction to the law of neural habit.

Examples of Illusions.—As another example of this class of illusions, we may suggest the well known one of two heavy, parallel lines, with additional lines radiating from a point between them. The straight vertical lines will appear to be curved. Or, if we draw a circle, and then from a point without the circle draw lines that shall spread out fan-shaped over the circle, the circle will appear to be flattened. It appears that this error in perception arises as the result of our experience with forces acting upon similar objects. It may well be ques-

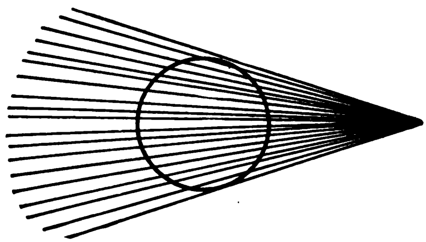

Fig. 28—Illusion of the flattened circle.

tioned whether a little child under the same circumstances would not see the circle exactly round, and the lines exactly parallel.

The Stairway Illusion.—If we look at the outline drawing of a stairway, we shall probably see it as the upper side of the steps at first; but by the proper kind of attention, we shall be able to see it as the under side. We can by an act of attention see it either way. It is probable that the upper side will appear to us at first, because we are likely to be more familiar with the appearance of the upper side of stair steps than with the lower. If we have never seen the lower side of the steps of a stairway, it will be impossible to see them in the drawing.

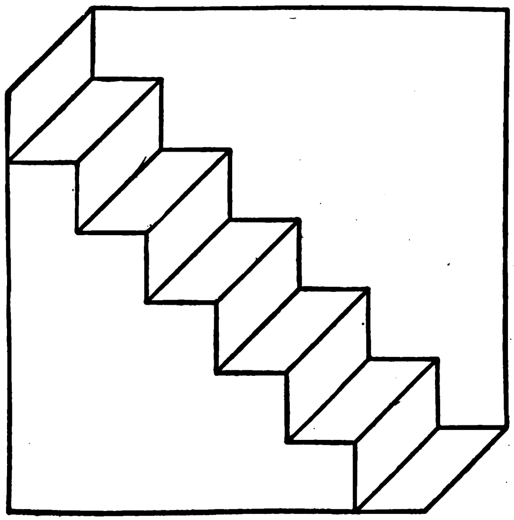

Fig. 29—The stairway illusion.

The Duck and Rabbit.—Similarly, we may see in the same picture, either a duck's head or the head of rabbit; and by a process of attention, we may see either at

a

Fig. 30—The duck and rabbit illusion.

will. But if we have been familiar with the appearance of a rabbit's head, and have never seen the head of a duck, the duck's head will not appear to us.

The Windmill.—If we watch a whirling windmill from a position about 45 degrees to one side of the direction of the axis, and from a distance of a hundred or two

Fig. 31—Puzzle picture: "Come and swing me, Harry." Where is Harry?

hundred yards, we shall by a process of attention, be able to see it turning in either direction.

Puzzle Pictures.—A puzzle picture is a negative illusion. In an illusion we see what we expect to see, as the result of habit and attention. But in a puzzle picture

we do not know what the thing we are searching for will look like, so we are unable to direct the impulse by a process of attention. Hence, instead of seeing what we expect to see, or seeing what we attend to, we know not what to expect, and are unable to attend; consequently we fail to see what is in the picture to be discovered.

Bearing upon Theory of Perception.—Hallucinations and illusions are anomalies of perception, which help us to understand the process better than we should be able to do without an explanation of them. A consistent explanation of hallucinations and illusions can be made understandable only by some hypothesis of the course of a nervous impulse. To say that the mind reacts in its customary way; or that consciousness interprets an appearance so and so, as is commonly done, would be verbally intelligible, but would really mean nothing, and is incapable of being translated into intelligible terms. By examining the physiological process involved in an illusion, we are led to an understanding of the complete perceptive process.

Projection of Images.—Certain other phenomena that are neither hallucinations nor illusions, are to be explained by the same principles of perception. Some persons are able to see an object as clearly after having ceased to look at it, as when it was actually present to the sense of sight. In extreme cases, the person who has merely glanced at the page of a book, without reading it, is able to project the page out into space and read the words on it. The phenomena are not at all unusual, and many persons who possess it are unaware of their ability to project images of this kind. Auditory images are projected also, and a person is sometimes able to hear the tones of another's voice whenever it is desired to do so. The projected images are not hallucinations, be-

cause they are not mistaken for the real object, but they are as vivid as if they were accompanied by a peripherally initiated impulse. In nearly all cases of visual projection, an after image appears when the eyes are closed, thus indicating that the projected image is accompanied by a retinal impulse.

Imaginary Playmates.—Many persons, especially young children, experience the presence of another person, usually a child or children of the same age, with whom the person plays. The appearance of the imaginary playmate is usually both visual and auditory, and the playmate can be seen and heard quite as clearly as a living child could be. In the larger number of cases, the playmate appears by the time the child is two or three years old, before the time of the child's first recollections, and continues until the age of seven to eleven.

How Explained.—The explanation is the same as that of hallucination. The centrally initiated nervous impulse becomes as strong as a peripherally initiated impulse would be, and the impulse probably flows backward to the retina, and an after image can be observed. Not often is the experience hallucinatory, for the child always knows the difference between the imaginary playmate and a real child.

Evidence of Spiritualism.—Such appearances as these are likely to be cited as evidence of the truth of the phenomena of spiritual manifestations, and in cases where the imaginary playmate comes to have attached to it the name and description of a dead child, the result is likely to be an unshakable conviction of the truth of the spiritualistic explanation. However, in many cases we are able to observe the growth and development of these imaginary playmates out of mere make-believe, and we can arrange a series of experiences shading by infini-

tesimal gradations from the purest make-believe without any visual appearance to that which produces the most profound conviction. The phenomena are to be explained by the fact that a nervous impulse of a high degree of intensity, is passing through a sight center corresponding to the appearance that has been developed.

Number Forms.—Still another series of phenomena deserve notice. Some persons perceive numbers in a very definite shape. Thus the number fourteen may be seen at a particular spot on a curved line, or a ladder, or broken line. The names of the months and the days of the week also take a definite arrangement. Those who experience the number forms find them very helpful in dealing with numbers and numerical calculations. There is not necessarily any similarity between the number forms of any two persons, and in very few instances are we able to gather any information about the process by which the number form came to assume the shape that it has. It is evidently associated with the liberation of a strong, nervous current which traverses some combination of cells in the sight center, and has become associated with the name of the number, and perhaps with the figure that represents it.

SIDELIGHTS

By illusion is meant a subjective interpretation of an objective impression.—*Höffding, Psychology, p. 145.*

It is only in special cases that centrally excited sensations can rise from their accustomed faintness to the vividness of sense perceptions. We then speak of them as hallucinations.—*Külpe, Psychology, p. 186.*

Several trustworthy observers have stated that they are able to call up at will visual sensations of definite quality and of equal vividness with those of external perceptions. These visual qualities are, as a rule, quite clearly distinguishable from ordinary memorial

images, and as in extreme cases they have been found to give rise to after images, there can be absolutely no doubt that the peripheral organs are concerned in their production.—*Külpe, pp. 434-5.*

DEFINITIONS

Hallucination.—An idea that is as vivid as a percept, and which is mistaken for it.

Illusion.—The concomitant of a peripherally initiated impulse which is carried to the wrong brain center.

Law of Neural Habit.—A statement of the fact that the transmission of an impulse through a brain center modifies the brain center in such a way that succeeding impulses encounter less resistance.

Imaginary Playmates.—Vivid appearances, usually both visual and auditory, with which some children play as they would with other children. The playmates are usually children, but may be grown ups, or animals. They persist from year to year, and differ from hallucinations principally in the fact that they are not mistaken for real persons.

Projection Image.—A vivid visual or auditory revival of a previously experienced percept.

Number Form.—A persistent mental arrangement of the numbers in a geometric form.

Mental Calendar.—A persistent mental arrangement of the days of the week or the months of the year in a geometric form.

CHAPTER XII

The Perception of Time and Space

Intuitive Ideas.—It was formerly believed that space and time are intuitive ideas. By this it was meant that the ideas of space and time are furnished by the mind itself, and are not derived in any way from experience. They have been called necessary forms of thought, and it has been denied that experience enters in any way into the acquisition of these ideas.

No Space Perceiving Sense.—We have no particular sense for the perception of space. In fact, we cannot perceive space at all, but we may perceive distance. By distance, we mean the relation that exists between two co-existent positions. We perceive the distance between two objects, or between two points on the same object.

Derived From Perception of Distance.—Space is an abstraction derived from a comparison and perception of resemblance between all of our perceptions of distance. Our senses are not equally efficient in affording us a measure of distance. Smell does not furnish us an idea of distance; neither does taste, nor equilibrium, although Mr. James asserts that all of our sensations have a spacial character.

Muscular Sense the Fundamental Sense in Perceiving Distance.—Hearing gives us some information about the distance that a sounding body is from us, but not a great deal. The primary sense upon which all of our perceptions of distance must ultimately depend is the muscular sense. This sense is often combined in the perception

of distance with the sense of touch, but not always nor necessarily so. We decide, by the amount of muscular effort required to move our hand from one place to another, how far the distance is. Our finger may be on one point and we may move it to another. The touch of the finger serves to delimit the distance, indicating the two ends of the line that measures it, but it is not necessary that we should touch anything in order to judge of distance. I may move my hand through the air without touching anything whatever, and I may judge merely by the amount of muscular effort involved in the moving, how much distance the finger has moved through. I know very well whether I have moved it through a short distance or a longer one. So it is really the muscular sense, and not the sense of touch, that enables us to judge of the extent of the distance.

Even in Long Distances.—Even in greater distances than can be reached by the length of the arm, we judge by means of the muscular sense. We judge of the distance between two places in town by means of the muscular effort expended in walking from one place to the other. One road seems to be a very long one if we have expended much muscular effort in traversing the distance, while another appears to be shorter if it has required less effort to pass over it. It is the muscular effort in every case that furnishes us our fundamental notion of difference in position which we call distance.

Perceived by the Eye.—As soon, however, as we have learned through the muscular sense to judge of distance, we begin to interpret the appearance of distance with the eye, and this immensely extends the distances we are capable of observing. Even here, however, it is the muscular sense that enables us to judge of distance. When we wish to look at an object that is very

small we hold it about ten inches from our eyes. This is regarded by all microscopists and opticians as about the distance in which the normal eye can see the smallest possible object of which it is capable. In order to look at an object with both eyes at a distance of ten inches, we must exert some muscular force to turn the axes of the two eyes to the same point. It requires considerable effort to turn them to a point closer than ten inches, as every one may discover by following the end of his finger toward his nose until his eyes turn inward and he looks cross-eyed.

Muscular Sensations in Eye Movements.—When we look at an object twenty inches away, we need to turn the eyes toward the object, and the lines that run from the object to the two eyes make a different angle from that which they made when looking at it from a distance of ten inches. This difference in the amount of muscular effort exerted, and in the intensity of the muscular sensation experienced, enables us to judge that the second object is farther away than the first object was. So we may make a fairly accurate judgment of the distance of an object by means of the muscular sensation established in the rectus muscles of the eye, until the line connecting the two eyes, and constituting the base of the triangle becomes very small compared with the sides of the triangle.

How Judge Distance with One Eye.—A man who has only one eye can judge of distance, although not so accurately as can a man with two eyes. He judges the distance by means of the muscular sensation established, not in the rectus muscles that move the eyeballs, but the ciliary muscle by which the shape of the crystalline lens is altered.

When we look at an object that is near, the crystal-

line lens must be relatively convex in order to bring the rays of light to a focus on the retina. When we look at an object farther away, the lens needs to be flatter. This flattening of the lens is accomplished by a contraction of the ciliary muscles. The farther away the object is, the more tension must be exerted upon the ciliary muscles, so that by the greater or less intensity of the muscular sensation accompanying the impulse, we judge that the distance is much or little. A man with one eye has only one of these methods of judging distance, while a man with two eyes has both methods and is likely therefore to make a more nearly accurate judgment.

Effect of the Atmosphere.—These two methods of perceiving distance are not very reliable beyond the distance of 100 feet, and indeed beyond 50 feet the judgment is not likely to be very accurate. But we need to judge of distances greater than this. When we look at a steeple or a tree a mile or more away, we judge of its distance by the sharpness or clearness of its outline. There is always more or less dust and water vapor in the atmosphere, which constitutes a haze, rendering the objects that are distant less distinct than those that are near. When we are fully acquainted with the atmosphere, we are not likely to make great mistakes in judging distance; but if the atmospheric conditions are unfamiliar, we may make serious errors. Nearly all persons from the Eastern states who go to the western plains or mountains experience considerable difficulty in estimating distances in consequence of the unfamiliarity with the atmospheric conditions.

Muscular Sense Indirectly.—Here the immediate judgment is not made by means of the muscular sensation, but we have learned to interpret the sharpness of

outline, and to estimate the haze in the air at first by means of it. So even here the muscular sense enters indirectly into the judgment of distance.

Shape.—We estimate the shape of objects in the same way. Shape depends upon the relative distance between different sides of the object, and the distance between any two points on an object is estimated by means of the muscular effort involved in moving the eyes from one point on the periphery of the object to another.

Size.—Size is estimated by the same means. The primary judgment in estimating size is the distance that the object is from us. Two objects that subtend the same visual angle will be judged of the same size if they are the same distance away; but if one is judged to be farther away than another, which distance as we have seen is primarily determined by the muscular sensation, the one that is farther away will be judged the larger.

Moon on the Horizon and Meridian.—To nearly all persons the moon appears to be larger when we see it rising at full, on the horizon, than when the same full moon appears on the meridian. There is a wide difference in the estimates of the apparent diameter of the moon by different persons. To the writer, the moon appears to be three or four feet in diameter when seen on the meridian, while on the horizon the same moon appears to be from 40 to 60 feet. Nearly all normal school students in the writer's classes assert that the moon appears to be not more than a foot in diameter on the meridian and two or three feet on the horizon.

Distance of the Moon.—If the moon appears to be three feet in diameter on the meridian, it means that we estimate it to be at a distance of about 360 feet from us, approximately the distance of a short city block. The moon subtends an angle of about half a degree.

There are 360 degrees in a circle, so it would require 720 moons to fill the circumference. If the moon appears to be three feet in diameter, the circumference of the circle would be 2,160 feet, the diameter about 720 feet, and the radius of the circle, which would be the distance of the moon, 360 feet. Similarly, if the moon appears to be 40 feet in diameter on the horizon, that is evidence that we judge it to be about 4,800 feet away from us, or slightly less than a mile.

Solidity.—We judge the solidity of an object primarily by means of the muscular sense, in passing our hands over it and around it. But later, and secondarily, we perceive solidity with the two eyes by means of binocular vision. If we look at a cylindrical post, whose diameter is not greater than the distance between the eyes, we shall be able to see half of the surface with one eye. But while one eye sees half of the surface, the other eye sees a somewhat different half; consequently the two eyes see rather more than half of the surface, or they together see somewhat around and behind the object. It is this additional surface that enables us to perceive the post as solid.

Stereoscopic Pictures.—Stereoscopic pictures are made by taking two photographs from slightly different points, such that the two pictures will represent the images seen by the two eyes. Thus we shall experience exactly the same sensation that we do when we see the object with two eyes. The difference in the appearance of the images made upon the two eyes is very slight, and it probably requires considerable experience to enable us to interpret this slight amount of difference. The probability is that if a person were born blind, and acquired considerable intellectual culture before obtaining sight, he would not perceive solidity or dis-

tance by sight until he had learned to interpret his impressions by means of the sense of muscular effort.

Lights and Shadows.—Much the larger part of our impressions of solidity, however, is derived not directly from binocular vision, nor muscular sensation, but even more indirectly from unconscious inference, by a judgment of light and shadow, represented by an object. When we look at a well-painted picture it is the correct rendering of light and shade that gives us the impression of solidity. Originally we learned to interpret the appearance of the lights and shadows by means of the muscular sensation, but when we have once learned to recognize what our muscular sensations would be in the circumstances presented, we no longer need to experience the muscular sensation to perceive or infer the solidity.

Square Misjudged; S and 8.—If we look at a square on the blackboard, it will seem to us that the vertical dimension is greater than the horizontal. This is true unless we know that the object is a square, and reason ourselves out of the impression. If we draw a horizontal line through the middle of the square, we shall imagine that the top half is larger than the bottom half. If we look at the letter S or the figure 8 we shall see that the top and bottom parts of the two printed impressions appear equal; but if we turn the paper and look at the two characters upside down, we shall see that what was the bottom portion and is now the upper part is considerably the larger. The larger size of the bottom part is necessary if we wish to get the impression that the two are equal.

Framing Picture.—Similarly, if we wish to frame a picture so that the margin of matting at the top and bottom shall appear to be equal and give a symmetrical impression, the part at the bottom must be decidedly

larger. A picture is not well framed if the part of the matting which shows at the top measures the same as that which is shown at the bottom.

Explanation of Space Illusions.—The explanation of these so-called illusions is not easy. It appears, however, to be found in the amount of muscular exertion required to turn our eyes throughout different portions of the field of vision. The muscles that move the eyes upward are attached to the eyeball in such a way that more force must be exerted by them to move the eyes through a given arc, than must be exerted by the muscles that move the eyes downward through the same arc. It requires a greater amount of muscular effort to raise our eyes through an arc upward than it does to lower them through an arc downward. Hence we judge that the top portion of an object is larger because we have expended a greater amount of muscular effort in causing our eyes to traverse the upper portion than we have in causing them to traverse the lower portion. We judge of the amount of distance by the amount of muscular sensation, or nervous energy expended, and consequently we make an incorrect perception.

Why Not See Things Inverted.—We are sometimes confronted with the question why it is that we do not see things upside down, since the image on the retina is inverted. The position of the image has nothing to do with the matter directly, since it is not the image that is perceived, but the object. There is no way by which a person is himself aware of the fact that an image has been formed on the retina, but the position of the object that is seen is determined by the direction in which the muscles must act in order to turn the eye to the top and the bottom. If the muscles need to pull the eye upward in order to see a particular point on the

object or to cause the image of the point to fall on the fovea, that point is judged to be at the top, or above. If the muscles must pull the eye downward to see the point, that point is at the bottom, or below. So our judgment of the top and bottom of an object that is perceived is determined by the muscular sensation.

Perception of Time.—All that we have said about the nature of space may with equal propriety be asserted of time. Time has been regarded as an intuitive idea, as a necessary form of thought, and as underivable from experience. It appears, however, that all of our ideas of time are derived from experience. Time is the abstract of the intervals between sequential events, as space is the abstract of coexistent positions.

No Time Sense.—We have no sense by means of which we perceive time directly, any more than we have for the perception of magnetism, or ether or electricity. But we can perceive the interval between events, and by a process of abstraction and generalization we arrive at our notion of time.

See Dun Real p31

Pulsation of Consciousness.—We have within ourselves a time measure, although it is not a time sense. We experience a pulsation of consciousness, which is the interval that a single molecule in a nervous arc can change from colloidal to crystalloidal and back again without a rest. It is nearly the interval the attention can be held upon a single aspect of an object. It differs in different individuals, and is not constant in the same individual at different times. This pulsation of consciousness is the real, or specious present, and can not be described in any of its parts as either past or future. It is our immediate measure of time intervals.

The Primary Interval.—Our judgment of the time that elapses between two events is determined primarily

by this pulsation of consciousness. We later estimate the interval between other events by means of this pulsation of consciousness, and then employ these secondary measures as a means of measuring longer intervals. Heart beat, respiratory movements, times of getting hungry and other bodily functions may all of them be employed secondarily as means of estimating time.

Rhythm.—The pulsation of consciousness results in the acquisition of rhythm. By rhythm we mean the accented measure in which we walk or talk or think. The most common is the one-two rhythm, and is acquired not merely from the pulsation of consciousness, but by means of our movements. In walking there is an alternate one-two movement of the legs, and even in the movement of one leg there is the alternation of the press-swing that is the beginning of rhythm. We are assisted in the acquisition of rhythm by our sense of sight. Pendulums vibrate; trees sway; waves come and go; the arms swing in walking, and even the sounds of a bell and other noises that occur regularly bring the aid of hearing to rhythm acquisition.

One-two-three Rhythm.—The acquisition of a one-two-three rhythm is more difficult and comes mostly through hearing, although it may be learned by movement. There are fewer examples of one-two-three rhythm within our experience than of the one-two rhythm. The waltz movement is more difficult to acquire than is the march movement. When the one-two-three rhythm and the one-two rhythm have been acquired any other rhythm may be obtained by combination.

Importance of Rhythm.—All of our musical appreciation originates in rhythm, as well as the enjoyment of dancing, and a large part of the satisfaction derived from reading poetry. Hence it is that all teachers try

to develop the idea of rhythm. With deaf children this is a difficult matter. Teachers of the deaf sometimes cause children to put their hands, or their teeth, on the top of a piano while it is played with a strong accent. Dancing, and especially the waltz movement, is taught laboriously and painstakingly as a means of inculcating the idea of rhythm.

Time to a Child and a Man.—A year seems much longer to a child than it does to a man. The years seem to become shorter as the person grows older. This is an universal experience, and seems to be accounted for by the fact that a year represents a different proportion of the person's life. To a child of six, a year represents one-sixth of his whole life, or perhaps a third of the only life that he can remember and compare with it. To a man of 40, one year is only one-fortieth of his existence. Hence, in comparison, the year seems much shorter to him.

SIDELIGHTS

Space is the abstract of coexistent positions.—*Lewes, Problems of Life and Mind, First Series, Volume II, p. 486.*

The retina has no power of perceiving relations of contiguity or position among its parts. This perception is due to the movement of the muscles of the eye.—*Ribot, German Psychology, p. 121.*

When the moon is high above our heads we have no means of estimating its distance from us, since there are no intervening objects with which we may compare it. Hence we judge it to be nearer than when, seen on the horizon, it is farther off than all terrestrial objects. Since the size of the retinal image is the same in the two cases, we reconcile the sensation with its apparent greater distance when seen on the horizon, by attributing to the moon in this position, a greater actual size.—*American Text Book, Volume II, p. 355.*

Even in ourselves the respiratory intervals, joined sometimes with the intervals between the heart's pulses, furnish part of the materials from which the consciousness of duration is derived.—*Spencer, Psychology, Volume I, p. 215.*

Vertical distances are overestimated as compared with horizontal distances, because the adjustment of the eye muscles makes vertical movements of the eyes more difficult than horizontal.—*Pillsbury, Essentials of Psychology, p. 164.*

DEFINITIONS

Intuitive Idea.—An idea furnished by the mind itself, not derived from experience.

Distance.—The relation between two points, or positions.

Space.—A real existence, our knowledge of which is derived from an abstract of coexisting positions and generalized distances.

Time.—A real existence, our knowledge of which is derived from an abstract of sequential events, and generalized intervals.

Pulsation of Consciousness.—The time that a molecule in a nervous arc can change from colloidal to crystalloidal and back again without a rest.

Specious Present.—The time of the pulsation of consciousness that is in progress at any one instant.

CHAPTER XIII

The Thinking Process

The Intellectual Process.—A sensation makes us know a quality of an object. The process of perception makes us acquainted with an object, or the sum of the qualities that are made known to us by our sensations. But perception is not limited to the perception of a material object. We may perceive objects, events, processes, changes, movements, and other kinds of things. These various objects of knowledge may be made known to us by the process of perception, and we may call them all things.

Perception of Relations.—All of our knowledge consists of a knowledge of things and a knowledge of relations. We obtain our knowledge of things by the process of perception, but our knowledge of relations we obtain by the process of thinking. We usually describe the process by saying that we perceive relations, but the word perception in this case means a different process from what it does when we perceive things. In order to understand what we mean by thinking we shall need to know what we mean by relations.

What Relation Is.—If two things exist in the same place, they resemble each other in their position. The element of position is the same quality in each. Even though the two things are found in the same city, or state, or country, we may say that they have the same position, or belong to the same geographical or political unit.

This relation of similarity in position is usually described under the name of contiguity.

Other Relations.—Two objects or events that have existed at the same time, or the same historical epoch, are related in the character of time. This is the relation of coexistence. So two things that are unlike, and form the terms of a contrasting pair, like a tall man and a short man, are related by contrast. But they resemble each other in the fact that they are both men, and belong to the same order of existence. If two things do not belong to the same order of existence, and do not have many points in common, no contrast can exist between them. So we may describe other relations by the names of cause and effect, part and whole, substance and quality, similarity. Any one of these terms names a relation.

Every Relation Some Form of Resemblance.—If we examine the relations that have been named, we shall find that every one of them is a form of resemblance. We may use the word like or same in describing the two things between which the relations exist. The likeness or sameness may exist in only a single, or a very few qualities, but those qualities will be found identical in the two objects.

Resemblance Includes Difference.—All thinking consists in the perception of relations, and all relations are capable of being reduced to the form of resemblance. However, we shall find that it will be convenient to understand that resemblance may be used in a sense comprehensive enough to include difference, and it would be perfectly proper to say that all of our thinking consists of the perception of resemblance and difference. We have seen that in contrast, which is the relation of difference, we have a very complete form of resemblance. So we can show that in order that two things may be like

each other, there must be a difference between them. If there were no single quality of difference, neither time, position nor any other quality, there would not be two things to resemble each other, but only one thing. So in order that there may be two things to resemble each other there must be a difference, and the fact that a difference exists implies that there is a resemblance.

A General Abstract Notion.—If we put together all the resemblances that exist among a series of objects, and leave out of consideration their differences, we shall have what we may describe as a general abstract notion. This general abstract notion is easily understood if we recognize it as the content or meaning of a common noun. A common noun is the expression of a general abstract notion, and the notion that it expresses is a table of resemblances, and is not a real material object. There is no such thing as a general abstract cow, although our necessary use of the word cow to designate a creature whose proper name we do not know leads us to believe that cow means real thing. The real thing is a singular concrete notion, which is properly expressed by a proper noun.

How We Perceive Resemblances.—We can best understand the process of thinking, or perceiving relations, by picturing the process to ourselves in physiological terms. When we experience sensations, or perceive an object, a nervous impulse traverses some combination of cells in the brain. When the nervous impulse leaves this combination it passes into some other combination that offers little resistance to it. If we picture to ourselves the first combination as a circle, and the second combination as a second circle having a common section with it, we shall be able to understand the process. Let one circle be called A and the other circle B, and the common

section X. Then the nervous impulse passes readily from A to B because the common section X offers little resistance to the passage. The section X is common to the two circles, and the transmission of the impulse through the common cells which the section X represents will be the physiological concomitant of the perception of resemblance between the two objects.

Judgment.—In the process just described, we perceive the resemblance between two objects, events or processes directly. This process of perceiving the resemblance be-

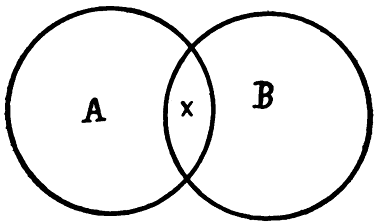

Fig. 32.

tween the two objects directly is called judgment. By judgment we may perceive a resemblance or a difference. The expression of a judgment is called a proposition. The expression of a judgment of resemblance is called an affirmative proposition, and that of difference a negative proposition.

Diagram of Resemblance and Difference.—A diagram will show us how we may think of the perception of resemblance and difference as the concomitant of the same process. Let circle A consist of two parts, m and x. Let circle B consist of two parts, n and y. Suppose that the part x of one circle and y of the other are identical, and constitute the section that is common to the two circles. Then m and n are the uncommon sections. The judgment of agreement would be expressed by saying that x

is y. The judgment of disagreement would be expressed by saying m is not n. But there is the transmission of only one impulse through both the common and the

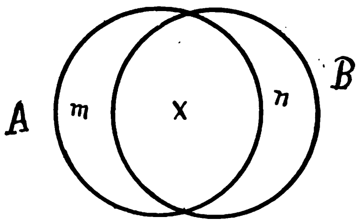

Fig. 33—Diagram to show affirmative and negative judgment.—(A) x is (B) x: M is not N.

uncommon sections, so we shall see that every judgment of agreement implies or necessitates a judgment of disagreement, and every judgment of disagreement implies a judgment of agreement.

Parts of a Proposition.—A proposition is the expression of a judgment. Every proposition involves three elements—the subject, predicate and copula. The predicate is the expression of the notion that is used as the standard of comparison, and the subject is the expression of the notion that is compared with the predicate notion. The copula is the expression of the judgment itself. When we perceive the resemblance between two objects, we compare one with the other, which is used as a standard. There is this other difference between the subject and the predicate. Usually the predicate notion has greater extension than the subject notion, by which we mean that the characters which constitute the general abstract notion which is used as the standard of comparison belong to a larger number of individual objects than do the characters which make up the subject notion.

Reasoning.—In a judgment we compare two notions directly. But there are some notions which we wish to compare that cannot be compared directly, so we compare them indirectly by means of a third notion. This process is called reasoning, and the simplest form of it may be represented by a syllogism.

The Syllogism.—A syllogism is a series of three propositions so related that the third one can be derived from the other two. Thus in the propositions,

All insects have six legs;
A grasshopper is an insect;
A grasshopper has six legs;

we have a syllogism. The first proposition is called the major premise, the second is the minor premise, and the third is the conclusion. It will be seen that in the two premises there are only three terms, or notions. One notion, that of insect, is found in both. This is called the middle term, and the other two notions are compared separately with it. If the two notions agree with the middle term, or the notion the middle term expresses, we say that they agree with each other. By term we mean the expression of a notion, and by comparison we mean the perception of resemblance.

Syllogism and Judgment.—The syllogism is like a judgment in the fact that it consists in the perception of resemblance between notions, and it differs from a judgment in the fact that in a judgment the two notions are compared directly while in a syllogism they are compared indirectly by means of a third notion.

Diagram of a Syllogism.—The process of reasoning involved in a syllogism may be made clear by the following diagram: Let S, M, P be three circles with a common section x for S and M, and a common section y common to M and P. Then a nervous impulse starting into

S is easily transmitted to M by the common section x, and from there passes readily into the combination P by means of the common section y.

Unity of All Thinking Processes.—We thus see that all forms of thinking are capable of being reduced to the one process of the perception of resemblance. The different forms of thinking differ from each other merely in the greater or less degrees of complexity that they manifest. Since thinking consists in the perception of relations, and

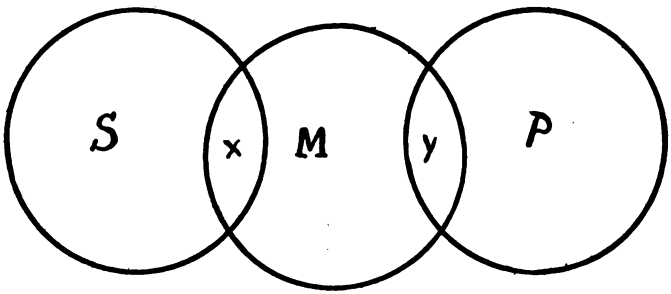

Fig. 34—Physiological interpretation of the Syllogism. Sx is M. My is P.

all relations are capable of being reduced to the form of resemblance, we may say that thinking consists in the perception of resemblance. We may discover the concomitant of the perception of resemblance in the transmission of an impulse through the cells that are common to two brain centers.

DEFINITIONS

Judgment.—Judgment is the perception of agreement or disagreement between two notions.

Affirmative Judgment.—Affirmative judgment is the perception of agreement between two notions.

Negative Judgment.—Negative judgment is the perception of the disagreement between two notions.

Proposition.—A proposition is the expression of a judgment.

Predicate.—The predicate is the expression of the notion that is used as the standard of comparison.

Subject.—The subject is the expression of the notion that is compared with the predicate notion.

Copula.—The copula is the expression of the judgment itself.

Syllogism.—A syllogism is a series of three propositions, two of which are so related to each other that the third may be derived from them.

Conclusion.—The third proposition in the syllogism.

Premises.—The two propositions other than the conclusion.

Term.—The expression of a notion.

Middle Term.—The middle term is the one that occurs in both premises.

Major Term.—The major term is the predicate of the conclusion.

Minor Term.—The subject of the conclusion.

Major Premise.—The premise that contains the major term.

Minor Premise.—The premise that contains the minor term.

CHAPTER XIV

Simple Reaction Time

Reaction Time.—Reaction time is the interval that elapses between the perception of a signal and a muscular contraction in response. It is the interval required for an impulse to be transmitted from the organ in which it is established to the muscle whose contraction constitutes the response. It is quite impossible to understand some of the phenomena of mental life without a knowledge of the facts of reaction time.

The Chronoscope.—Reaction time is measured by an instrument called a chronoscope. There are several forms of this instrument, but the one described here is perhaps the most easily understood. It consists essentially of a pendulum that is long enough and properly weighted to swing from one end of its arc to the other in half a second. It is supported on steel bearings like knife edges such as are employed in making delicate chemical balances.

The Pendulum.—When the pendulum is drawn to one end of its arc, a sharp edge at the bottom of the pendulum catches in one of a row of notches in the upper side of a ratchet. The ratchet is held in the proper position to receive the pendulum edge by a spring. When the ratchet is pushed or pulled down, it releases the pendulum and permits it to begin its swing.

The Pendulum Release.—The ratchet may be pulled down and the pendulum released in either one of two ways:—first, the distal end of the ratchet projects beyond

the axis that supports it and terminates in a key which may be lifted up by the hand, thus depressing the end of the ratchet bar that holds the pendulum, and so releasing it. Second, it may be released by sending a current of electricity through two coils of wire, which with their soft iron cores constitute an electro-magnet that

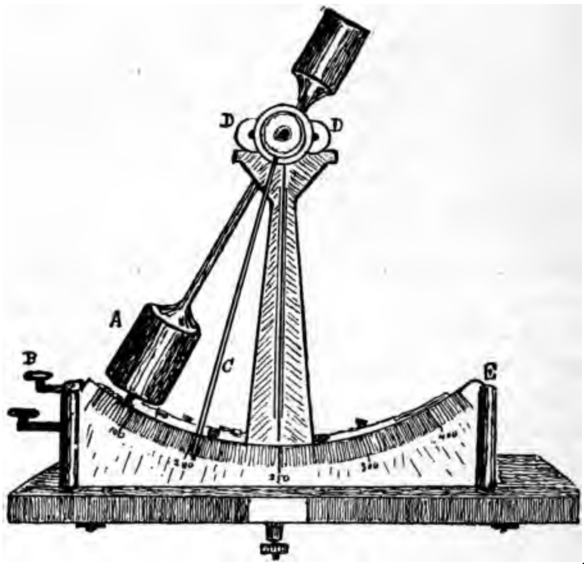

Fig. 35—Chronoscope. A, Pendulum; B, Pendulum release key; C, Indicator; D, Indicator control mechanism; E, Scale.

attracts downward a piece of soft iron attached to the ratchet bar. When the electro-magnet is energized by sending a current of electricity through it, the pendulum is released. When the current is broken, the ratchet is thrown back into place by a spring on its under side. When the ratchet is thrown up into its original position, the swing of the pendulum back to the end of its arc

from which it started carries the lower edge of the pendulum up into one of the notches of the ratchet and holds it there until again released. The releasing of the pendulum by closing a key which makes the circuit, sending thereby a current of electricity through the coils of wire, is the most satisfactory method.

The Indicator.—The pendulum is supported upon a pillar that rises from a heavy steel bed plate. The pendulum swings on an axis which carries on its front end a circular soft iron plate furnished with a slender indicator arm, nearly as long as the pendulum. The circular plate is not fastened rigidly to the axis, but may move upon it, and the indicator which it carries moves with the pendulum in its swing until it is stopped by the attraction of the circular plate to an electro-magnet in front of which it swings. The circular plate that carries the indicator moves in front of the two poles of an electro-magnet attached to the pillar which supports the pendulum. When the electro-magnet is energized by a current of electricity through its two coils, the magnet attracts the circular plate to its poles and holds it fast, thus stopping the indicator. When the current is broken, and the coils are demagnetized, a spring pushes the circular plate away from the poles and allows the indicator to continue its swing with the pendulum.

The Scale.—The indicator swings over an aluminum scale near the bed plate of the instrument, which is graduated into five hundred degrees. The pendulum swings from one side of the arc to the other in half a second, so that the indicator passes over the five hundred degrees of the scale in the same length of time, and consequently passes over one degree in one thousandth of a second.

Variation in Degrees.—The pendulum starts from a state of rest and comes to rest again at the extremity of

its swing. In its course it moves with a constantly accelerated motion through the first half of its arc, then with a constantly retarded motion through the second half. It is swinging slowest near the extremities of the arc, and moving most rapidly near the middle of its swing. It is evident, then, that if each degree is to be passed over in the same length of time, these degrees near the middle of the arc must be longer than those near the extremities. In fact, on the scale the actual gradations of the first and fifth parts are into five-degree spaces instead of into single degrees.

We have thus indicated the principal parts of the chronoscope, which are the pendulum, the method of pendulum release, the indicator, the indicator control mechanism, and the graduated scale. Other parts merely hold these essential mechanisms in proper position.

Operation of the Chronoscope.—In order to operate the chronoscope, the person whose reaction time is to be measured, is seated at a table with one hand upon a key which when pressed will close a circuit through the electro-magnet that stops the indicator. A single cell of a good dry battery will furnish current enough for this magnet. The signal is given in various ways, depending upon the sense that is to be measured.

Reaction to Sight.—If we are to measure the reaction to the sense of sight, the person to be measured is seated behind a screen in which is a hole about an inch in diameter, on a level with the eyes. A light wooden lever is attached to the release key of the chronoscope, and the distal end of the lever is inserted in a strip of cardboard in front of the screen. The strip of cardboard is of just such a length that the upper edge of it comes to the lower edge of the hole in the screen. When the distal end of the release key is lifted, either by energizing the electro-

magnet, or by the finger of the operator, the same movement that releases the pendulum throws the strip of cardboard up in front of the hole. The person perceiving this as a signal, presses the indicator key, thus stopping the indicator. The interval between the appearance of the signal and the motor response in pressing the key is then read off the indicator scale in thousandths of a second.

Reaction to Hearing.—The signal for hearing is given by the click of a telegraph key which is produced by the same current that releases the pendulum. In order that the person may react to hearing and not to sight, a screen is interposed between the person who reacts and the chronoscope.

Reaction to Touch.—The signal for touch is given by pressing one hand of the reactor with a key which closes the circuit, thus releasing the pendulum, while the person reacts with the other hand. The reaction time is the interval between the release of the pendulum coincident with the starting of the touch impulse in the skin of one hand, and the closing of the indicator key with the other.

Reaction Time Without a Chronoscope.—The reaction to the sense of touch may be measured quite accurately for the average of a large class without a chronoscope. Let all the persons in a class stand in such a way that they may form a complete circuit by joining hands. The first person in the circuit lets fall a pendulum of such a length that it beats seconds while at the same time he presses the hand of the person next to him. That person, when he perceives the pressure, presses the hand of the person next to him, and the pressure is thus transmitted through all the persons in the circuit. The last person in the circuit, when he feels the pressure, stops the pendulum. The number of seconds, divided by the

number of persons will indicate the average reaction time for the whole class.

Favorable Condition.—In order to make accurate measurements of reaction time, there should be as little distracting circumstances as possible. The presence of other persons in the room is very likely to modify the time measurement. Noises are nearly certain to influence the reaction. It is better to place the signal and the reacting key in a room where there is no other person than the one reacting.

Analysis of Reaction Time.—Reaction time is capable of being analyzed into several parts. The time required for the signal to establish a nervous impulse, the transmission along the afferent nerve, the time required for the impulse to traverse the sensory center, the transmission from the sensory center to the motor center, the transmission through the motor center, the transmission along the efferent nerve, the time of muscular contraction, and the time for the electric current to traverse the wire to the indicator. However, all these times are so short, except the transmission along the nerve and through the two brain centers that there is likely to be a greater error produced by trying to take them into account than if they were neglected. In order to obviate errors to as great an extent as possible, it is usual to make several measurements and take an average.

The Fact of Reaction Time.—From measurements of reaction time, several important conclusions have been obtained. The first important fact is that there is a measurable reaction time. Scarcely more than sixty years ago, the great physiologist, Johannes Müller, asserted that it would be forever impossible to measure the time of the transmission of an impulse, and within five years afterward it was measured.

Length of the Interval.—The reaction time varies around 200 sigma. A sigma, represented by the Greek letter of that name, σ, is the unit for small intervals of time, and is the one thousandth of a second.

Variation in Different Persons.—The reaction time varies for different persons in the same sense. With some persons the reaction time for the sense of sight may be as small as 150 σ, while with others it may be as great as 250 σ.

Variation in the Same Person.—The reaction time varies for the same person in different senses. Some persons have a reaction time of 150 σ for hearing or touch, while that for sight may be 200 σ or more. In general, those persons who have a noticeably short time for sight and longer time for hearing are called eye minded individuals. They are likely to learn better through the eye, and to make accurate judgments of size and shape, and will be likely to have pronounced ability in drawing. Those in whom the reaction for hearing is decidedly the shorter, are likely to learn better by hearing, to be good oral readers, to have more or less ability in musical subjects. However, this difference in reaction time is not a positive indication of ability in any one of these artistic directions.

Effect of Practice.—Practice diminishes reaction time. This is a fundamental fact of psychology which it is necessary to recognize. We may not be able to understand the process by which the reaction time is decreased, but it is necessary for us to realize that the fact occurs. When a nervous impulse passes through a brain center, or nervous arc, for the first time, it encounters resistance. The second time it passes through, it encounters less resistance, apparently in consequence of some modification of the nerve cells of the arc itself. This shortening

of reaction time is the fact which lies at the basis of the formation of habit. No amount of practice, however, can shorten reaction time below about one-tenth of a second.

Effect of Attention.—Attention modifies reaction time. This is the source of the greatest variations that are encountered. Any circumstance that distracts attention increases reaction time. The precautions that it is necessary to take in order to get a true test of reaction time are precautions against a distraction of attention. The variations that occur in successive reactions are sure to have their origin in the variations of attention, and this fact is one of the phenomena that must be considered in any theory of the nature of attention.

Motor and Sensory Reaction.—Motor reaction is shorter than sensory. By motor reaction we mean that which follows when the attention is fixed upon the hand and muscle with which the movement is made. By sensory reaction we mean that which follows when the attention is fixed upon the signal, or stimulus. In every case it is found that the hand can move more quickly after the signal is given, if the idea of the movement, instead of the idea of the signal, is kept in mind.

Reaction Time in Children.—The reaction time of children is longer than that of grown-up persons. This must be taken as a general fact. It is not true that the reaction time of every grown-up person is shorter than that of every child, but that the average reaction time of a thousand grown-up persons will be shorter than that of a thousand children. Also, it means that if the reaction time of a child is measured, it will be longer than the reaction time of that same child after he has grown up.

Reaction Time in Educated Persons.—The reaction time of educated persons is shorter than that of uneducated persons. In this case also it must be understood

that there are many individual exceptions, and that it is only by taking the average of large numbers of educated and uneducated persons, as well as by considering what may properly be called education, that we can demonstrate that the proposition is true. However, there can be little question of the general truth of the proposition, and that one effect of education is to diminish reaction time.

Effect of Fatigue.—Fatigue increases reaction time. This effect of fatigue is shown rather promptly and decidedly. Reaction time may be employed as a fairly satisfactory method of studying the intensity of fatigue.

Effect of Disease.—The state of health modifies reaction time. In general, sickness, or poor health, or pathological condition of the body increases reaction time. But there may be some kinds of disease, characterized by extreme nervousness, in which the pathological condition may act to decrease reaction time. If the reaction time should go decidedly below 100 σ, we may suspect a nervous condition that borders on the pathological.

Demonstration of Resistance in the Brain.—It requires from ten to twenty-five times as long for the nervous impulse to traverse a given distance in the brain as it does to travel the same distance in a nerve. The demonstration of this fact is comparatively easy. Let us take an example in which the reaction time to the sense of touch is 187 σ.

Rate in a Nerve.—In this interval of time, the nervous impulse started in the left hand has traversed about three feet of nerve in the left arm and about three feet in the right, before going to the muscles that move the fingers. The impulse has thus traversed about six feet of nerve. All measurements of the rate of speed in a nerve show that it moves at a rate approximately constant and

about 100 feet in a second. It has then required six-hundredths of a second to traverse the six feet of nerve. The difference between 187σ, the total reaction time, and 60σ, the time thc impulse employs in traveling six feet in the nerve, is 127σ, which is the time occupied in traversing the brain. The distance that the impulse travels in the brain cannot be greater than six inches, and may be much less. Besides, part of this distance is along an association fiber connecting the sense center with the motor center, and having the same transmission rate as a nerve. Six inches is the longest distance that we can suppose the impulse to travel in the brain, and anything less than that merely makes the demonstration so much the more emphatic.

Rate in the Brain Center.—If it requires 127σ to traverse six inches in the brain, it would require twice that time, or 254σ, to go one foot in the brain, and 25 and four-tenths seconds to traverse 100 feet, or more than 25 times as long as it requires to traverse the same distance in a nerve.

Rate in the Brain Center Variable.—The rate of transmission in a nerve is constant, while in a brain center it is variable. All measurements of the rate of transmission in a nerve arrive at approximately the same result, while there are scarcely two measurements of reaction time, even in successive trials with the same person, that do not show more or less variation. We are compelled to suppose then, that the variation in reaction time is associated with the transmission through the brain center, not in the nerve.

Rate in Cell Body and in the Nerve.—The nerve fiber is merely a prolongation of the neuron, and is part of a cell, containing the same essential constituents. There is no reason for supposing that the matter of the cell dif-

fers in any degree in its conducting power in any part. A nervous impulse would travel as rapidly, and at exactly the same rate, in the cell body or the dendrite as it would in the axon of the nerve fiber.

Delay at the Synapse.—We must suppose, then, that the hesitation, delay, slowing up of the nervous impulse in its passage through a brain center occurs, not in the cell, but at the synapse, where the impulse passes from one cell over to another.

Delay a Condition of Every Mental Process.—But the most far-reaching generalization derived from our measurements with the chronoscope and the demonstration of reaction time is that if it were not for this hesitation, delay, resistance, slowing up of the nervous impulse in transmission through a brain center, there would be no mental process other than that kind which is manifested in a reflex act, such as is seen in the knee jerk when the patella is struck. It is believed that without this delay in transmission through a brain center, we should experience no feeling, sensation, perception, memory, will, attention, nor any other process that we call mental. This is the meaning of the quotations from James, Morat and Ladd at the end of this chapter. It is a fact that constitutes the basis of all of our subsequent explanations of psychological phenomena.

SIDELIGHTS

We know that nervous substance resists the incoming of stimulation. The resistance that it offers can be overcome only by stimuli of a certain strength.—*Titchener, Outlines of Psychology, p. 96.*

The nervous substance of the central organs offers a greater resistance to the progress of a nerve commotion than is offered by the nerves.—*Ladd, Outlines of Physiological Psychology, p. 174.*

We have then in the results of this series of experiments a confirmation of the inference already suggested by the long duration of reflex time; that the central elements offer incomparably more resistance than the nerve fibers to the progress of an excitation.—*Wundt, Physiological Psychology, p. 88.*

Reaction to light lasts about 80 σ longer than the reaction to sound and pressure. Sensorial reaction lasts about one-tenth of a second longer than the muscular.—*Külpe, Psychology, p. 407.*

It is certain that cells are more inert than fibers, and that rapid vibrations in the latter can arouse only relatively simple states or processes in the former.—*James, Psychology, Volume I, p. 156.*

All consciousness seems to depend upon a certain slowness of the processes in the cortical cells.—*James, Psychology, Volume II, p. 104.*

The more these functions (intelligence) assume a psychical aspect, so much the longer is the duration of the impulse in the nervous system.—*Morat, Physiology of the Nervous System, p. 277.*

The intensity of consciousness as a neural function depends upon the intensity of the decomposition of the brain tissue. And it is inversely as the ease and rapidity with which the inner work of one nerve element is transmitted to another.—*Ladd, Outlines of Physiological Psychology, p. 417.*

The average time for associations is always slower for children than the average for adult persons.—*Münsterberg, Psychology and the Teacher, p. 155.*

It is highly probable that the chief resistances to the passage of a current lie at the synapses, or junction between neurons.—*McDougall, Body and Mind, p. 342.*

DEFINITIONS

Chronoscope.—An instrument for measuring short intervals of time. Usually it measures to the thousandth part of a second.

Sigma (Represented by the Greek letter σ).—The unit in michronometry. It is the thousandth part of a second.

Simple Reaction Time.—The time that elapses between perceiving a signal and the motor response. The time required for an impulse to travel from the sense organ in which it is started through the brain center to the muscle that contracts in response.

CHAPTER XV

Feeling

Meaning of Feeling.—The word feeling is used with several meanings. We speak of feeling, sometimes, meaning the exercise of the sense of touch. We may speak of feeling the top of the table, or the smoothness of a piece of glass. We may mean by feeling the general state of our health, as when we say that we feel bad, or sick, or well. Sometimes a picture is described as manifesting much feeling, meaning that it exhibits certain properties likely to arouse in the beholder considerable emotion. Feeling is also used to mean an affective process of a particular degree of complexity, corresponding to an idea.

Meaning Employed Here.—None of these meanings constitute the content of the word as it is used in this chapter. By feeling we shall mean any kind of affective process, simple or complex, vivid or faint, pleasurable or painful. Feeling will be employed to designate any kind of affective state, whether such as accompanies a fit of anger, or the scratch of a pin.

Affective State.—It will be necessary for us to understand what we mean by affective state, and to distinguish it clearly from an intellectual process. An intellectual process such as sensation, or perception, gives us knowledge, and makes us acquainted with the quality of an object, or with the object itself. An affective process does not make us know anything, but makes us experience pleasure or pain. If we were to say that an affec-

tive process is the pleasure or pain, we should make an incorrect statement, but it would assist us in arriving at a distinction between an affective and an intellectual process. Pleasure and pain are not affective processes, but they are their most characteristic properties, and affective processes can most clearly be distinguished by them.

Older Treatment of Feelings.—The treatment of the feelings is the most unsatisfactory department of psychology. The older psychologists divided the powers of the mind into three groups: the intellectual powers, or the group of powers by which we know; the sensibilities, or the group of powers by which we feel; and the will. The usual plan was to treat fully the intellectual powers, then proceed to the discussion of the sensibilities, and finally of the will. The relation between the intellect and feeling was not always made clear. In fact, the intellectual powers and the sensibilities were treated as if they were entirely distinct processes. While the admission was made that there was a relation existing between intellect and feeling, no one was able to suggest what the relation was, and no necessary connection was really recognized.

Treatment By the New Psychology.—The treatment of the feelings by the New Psychology has been scarcely more satisfactory. The movement that may be designated as the New Psychology may be said to have fairly begun with the work of Wundt, not far from 1870, and to have become established in the United States with the publication of James's Psychology in 1890. It is especially characterized by the much greater emphasis placed upon the study of the nervous system and physiological processes in general. This has brought about a complete transformation of the subject, but the im-

provement has been almost wholly in the study of the intellectual processes, and but little improvement has been made in the treatment of the feelings.

Difficulty of the Subject.—It seems as if the feelings have almost entirely escaped all attempts to associate them with physiological processes. If we except Mr. James's theory of emotion, which is almost certainly not true, we shall find no improvement in the New Psychology over the Old in the treatment of the feelings. Mr. Ladd, in his Outlines of Physiological Psychology, says that, "Since the beginning of serious attempts to establish a scientific psychology, the consideration of the feelings and emotions has been unsatisfactory."

Separation of Feeling and Intellect.—The tendency of the present day psychologists has been to regard the feelings as quite as independent from intellectual processes as it was among the older psychologists. Most of the psychologists of the present day see no necessary connection between intellect and feeling, and are unable to discover any way to fit the feelings into the physiological plan. Sometimes it is assumed that there are separate brain centers for different feelings, as there are for the different intellectual processes. Some of our popular school text-books on physiology indicate on the surface of the brain an area designated as the location of the feelings. Mr. Ladd in his "Physiological Psychology" is inclined to assume that there are parallel systems of end organs, nerves and brain centers for feelings and for intellectual processes; that the nerves which transmit the feeling impulses are distinct from those that transmit the intellectual impulses. If there are separate nerves there must be separate brain centers.

Feeling as Indefinite Intellect.—A different tendency is manifested in rather a strong disposition to regard feel-

ing as a process not differing essentially from an intellectual process, except in its clearness and definiteness. A feeling process when it becomes definite is an intellectual process. It seems that it is in consequence of this tendency that there has arisen a theory that pain is an intellectual sensation, with its own end organs, pain nerves and brain centers. The theory is widely held, although no pain end organs nor pain nerves nor pain brain centers have ever been demonstrated, nor is there any special stimulus for pain as there is for every other sensation. But it appears that this is the first step toward a definite reduction of feeling to an intellectual process, and it has therefore received very general support from psychologists.

Necessity for a New Theory.—Perhaps the greatest need in psychology today is some consistent theory of feeling that shall express its relation to other mental processes, and be in harmony with the tendencies of present day psychology, as well as correlate all the facts of feeling that we daily experience. What has been said in preceding paragraphs seems to justify the attempt to present a theory that is somewhat different from any theory at present advanced. This theory may be called the resistance theory, and is foreshadowed by the expressions quoted from Ribot, Höffding, Spencer and McDougall at the end of this chapter.

The Theory Stated.—Stated briefly, this theory is that feeling is the psychological concomitant of the resistance that a nervous impulse encounters in passing through a nervous arc. Measurements with the chronoscope show that there is a resistance through a brain center. We find that the rate of transmission is 10 to 25 times as rapid in the nerve as it is in the brain center, and that the rate in the brain center is variable. The fact of this

resistance is undeniable, and is recognized by all psychologists. We know nothing of the nature of the resistance, and know only that it exists.

Analogy of the Electric Circuit.—We shall be able to understand the character of the resistance by examining the analogy of the electric circuit. The current that is employed in our projection lantern is a current of 110 volts, which is too much to work satisfactorily. Therefore we insert into the circuit a coil of iron wire whose only function is to offer resistance, and to keep out some of the current. The current that goes through produces the light. We might connect it up with a motor and make it turn a fan or a mill or run a street car. That would be work done, and would correspond to the part of the nervous current that goes through the arc, and which is the concomitant of the intellectual work that is accomplished.

Analogous to Heat.—But that part of the electric current that is kept out by the rheostat is used up in overcoming resistance, and is transformed into heat. This is the part of the electric current that is analogous to that portion of the nervous current which is used up in overcoming resistance, and which is the concomitant of feeling. Feeling then, strictly is analogous to the heat produced in the electric circuit, and we may describe it by saying that it is the concomitant of the overcoming of the resistance, or more briefly that it is the concomitant of the resistance encountered in the transmission through the nervous arc.

Cause of Resistance Unknown.—We must not carry the analogy too far. We speak of the resistance in the electric circuit and measure it in ohms. We know nothing whatever about the cause of the resistance in the electric circuit, nor why an iron wire offers more resistance

than does a copper wire of the same length and diameter. Nevertheless, we are able to measure it very accurately, and to construct machinery that involves the employment and the accurate calculation of the resistance. In the same way, we know nothing about the cause of the resistance in the nervous arc, although we are able to approximate an explanation of it more nearly than we are of the resistance in the electric circuit. But we have not as yet established a unit for it, and we are unable to measure it.

What Resistance Means.—It is necessary for us to have a clear understanding of what we shall mean by resistance, for by it we shall expect to explain and make clear many divergent, obscure and apparently contradictory phenomena. We are using the term resistance in a slightly modified sense from that in which it is employed in describing the phenomena of an electric current. As the term is employed in electricity it means the property of a conductor and its magnitude is measured in ohms.

Amount of Current Destroyed.—When we use the term resistance in discussing the nervous current, we consider it not merely as a property of the conducting nervous arc, but it will be measured by the amount of current destroyed. The amount of current destroyed will depend not merely upon the nature of the arc, but also upon the amount of energy that is transmitted along the arc, or enters the brain center.

The Two Factors in Resistance.—It will be seen that this definition is intended to cover two elements; first, the nature of the nervous arc; second, the strength of the current. Resistance, then, in the sense in which we shall use the term, depends upon two factors, both variables, and varying independently of each other.

First Law of Resistance.—We may state some of the laws of nervous resistance in the following manner: With a current of given strength, resistance will vary with the nervous arc through which it is transmitted. The resisting power of any nervous arc will be modified by various circumstances. In the first place, repeated transmission of an impulse through the arc will diminish its resisting power. This is sometimes called the law of neural habit, and is one of the best known laws of nervous action. Its explanation is to be sought for in the manner in which the molecular structure is restored after its equilibrium has been destroyed by the removal of atoms in the transmission of an impulse.

Modification of the Arc.—But it is not merely the number of repetitions of an impulse through a nervous arc that decreases resistance. The resistance in the arc will be modified more rapidly by a strong impulse than it will by a weak one. A smaller number of repetitions of a strong nervous current will modify the resistance of the arc as much as a larger number of weak impulses.

Modification by Other Conditions.—The resisting power of a nervous arc will be modified not only by practice, or habit, but by the blood supply at any particular time and the general pathological conditions of the nerve tissue. Inflammation of the nerve tissue, or the action of different kinds of drugs may modify the resisting power of any given nervous arc to a current of any particular strength.

Modification by Attention.—A third method by which the resisting power of a nervous arc may be modified is through the process of attention, whose discussion must be reserved for a subsequent chapter.

Second Law of Resistance.—A second law of resistance may be stated as follows: In a given nervous arc,

the amount of resistance encountered will vary directly as the strength of the current. As a consequence of this second law, we understand that if a current is feeble and weak, little resistance will be encountered in passing through a nervous arc, and there will be but little modification of the arc by it. If a current is strong, great resistance will be encountered, and much modification of the arc will result.

Variation in Strength of Current.—There can be no question that nervous currents vary widely in strength. The strength of the current at any time is dependent in some degree at least upon the amount of tissue that is oxidized. Blood supply, plenty of food, pure air, sufficient exercise to quicken the heart beat and send blood rapidly to the brain are all conditions that tend to increase the amount of tissue oxidized, and the amount of energy liberated. Narcotic drugs tend to diminish the oxidation of tissue, to weaken the strength of the current, to diminish resistance, and to deaden the feeling.

Peripherally and Centrally Initiated Impulses.—We can readily recognize the fact that a peripherally initiated impulse which starts in some sense organ is stronger than a centrally initiated one. The external forces that act upon sense organs are generally greater than the force which originates a centrally initiated impulse. It is even possible now to measure the pressure of light which was believed for so many years to be absolutely lacking, but it is scarcely possible to measure the force that can decompose a molecule of protagon and deprive it of some of its atoms. It is very possible, too, that the end organs of sense are devices for multiplying the effects of the external force, which is not likely to be true of the cerebral organs.

Relation of Feeling to Intellect.—This hypothesis of

the nature of feeling will help us to understand what is the real relation of feeling to the intellectual process which accompanies it. The two processes are described by Herbert Spencer as at once antithetical and inseparable. No feeling is ever experienced alone, but it must always be accompanied by an intellectual process. This is a fact of profound significance, and no other hypothesis has been proposed that satisfactorily explains it. There can be no resistance unless a current is passing through a nervous arc, and the concomitant of the transmission is an intellectual process.

First Law of Feeling.—We are now in a position to understand what Mr. Spencer means by saying that feeling and intellect are antithetical. The reciprocal relation between the two processes has frequently been noticed, and hundreds of illustrations of the fact have been experienced by every one. We may state the first law of feeling as follows: With a given amount of nervous-energy, the more feeling the less intellectual work can be done, and the less the feeling experienced the greater the amount of intellectual work.

Illustrations of the Law.—If we are experiencing a toothache, or great fatigue, or hunger, or cold, or any other form of physical discomfort, we are unable to accomplish the usual amount of intellectual work. Our ability to study is decreased, and our decision upon any matter cannot be relied upon to manifest its usual accuracy. Even an amount of pleasurable excitement is unfavorable to our best work. Quite as disastrous to intellectual work is a mental, as distinguished from a physical, feeling. Anger destroys our ability to solve problems, learn lessons, or commit to memory. Fear is equally destructive, and in fact any unpleasant mental feeling has a disastrous effect. Only less destructive is a

highly pleasant feeling, such as is experienced in anticipating a holiday, or some much desired event in the near future.

Other Illustrations.—A person is a poor judge of the merits of his own case, because he is likely to be experiencing a good deal of feeling in connection with it, and his intellectual judgment is deficient in consequence. The person who wishes to meet the arguments of an adversary, whether mental or physical, must keep cool and experience as little feeling as possible, for only by so doing will he have sufficient amount of intellectual capacity to meet them. If he dissipates his energy in feeling, he will not be able to cope with his adversary intellectually.

Second Law of Feeling.—Such examples of the reciprocal relation between feeling and intellect are those in which the concomitant resistance is determined in the larger part by the nature of the nervous arc itself. But there are other phenomena of feeling in which our second law of resistance most immediately applies. Whenever the resistance is determined principally by the strength of the nervous current, the relation between feeling and intellect is direct and not reciprocal. With a given nervous arc, the more feeling the more intellectual work can be done, and the less feeling the less intellectual work. The actual relation between intellect and feeling at any time is the resultant of these two laws. A failure to recognize both, accounts for the contradictory statements that different psychologists have made.. What could be more directly contradictory than the statement of Höffding (Psychology, p. 98), that "Cognition and feeling must thus stand in an inverse relation to each other. The more strongly one is manifested the less strength at the command of the other," and the statement

made by an old time book on Mental Philosophy (Haven, p. 378), "The range and power of the sensibilities, the mind's capacity for feeling, depends upon the range and vigor of the intellectual powers. Within certain limits, the one varies as the other. The man of strong and vigorous mind is capable of stronger emotion than the man of dwarfed and puny intellect."

Intellectual Men of Deep Feeling.—When we see the real relation between intellect and feeling, and understand the conditions upon which that relation rests, we see that both statements manifest a partial truth. Some men of deep feeling are men of great intellectual ability. Abraham Lincoln was a good example, and perhaps Colonel Parker was a better. In all cases of this kind, we shall find that such men are those who are capable of generating nervous energy in an unusual amount, so that while a large part of it is used up in overcoming resistance, and its concomitant feeling is great, there is still an unusual amount to be transmitted through the nervous arc, and manifest its concomitant intellect.

Interest in Our Work.—Here, too, we shall recognize the explanation of the fact that is so generally insisted upon, that we learn our lessons better and do better intellectual work if we are interested in the subject; that is, if we experience considerable feeling while engaged in study. Also that in order to remember anything successfully we should learn it with feeling. Whatever truth there is in such statements, and they are generally believed, arises from the fact that the feeling accompanying the study in which we are interested is the concomitant of resistance arising principally from the generation of energy in greater quantity. It is an application of our second law of feeling. When we are interested in studying our lesson, we straighten up, take deeper breaths,

step a little more firmly, contract the muscles more strongly, and thereby induce a more rapid circulation of the blood, and oxidize more nervous tissue. Were the feeling to arise from an increase in the resisting power of the nervous arc without an increase in nervous energy, the intellectual work would not be better done.

Children Creatures of Feeling.—Children are capable of but little intellectual work, although they manifest a great deal of feeling. A little child laughs or cries a large part of the time, and it seems about as easy for it to do one as the other. Both conditions of resistance are pronounced in the case of the little child, and both laws of feeling are coöperative. The little child generates a large amount of nervous energy, and at the same time its brain centers are poorly organized. Both conditions conspire to increase the amount of resistance, and its concomitant feeling is very great.

Effect of Habit.—The effect of habit or practice is to decrease the resistance which a nervous impulse encounters in passing through a nervous arc. We know as a matter of experience and observation that feeling tends to disappear from an habitual act. We may be set to doing something that at first appeals to us as very unpleasant; but if we keep at it long enough, we not only become skillful in doing the work, but we cease to experience the discomfort that we felt at first. The explation is easy, if we recognize that feeling is the concomitant of the resistance that is overcome. Practice renders the resistance less, and the feeling decreases.

Unpleasant Becomes Pleasant.—An unpleasant occupation is more likely to become pleasant than a pleasant occupation to become painful. We nearly always like to do any kind of work in which we have attained a high degree of skill, and we believe that the skill is the cause

of the pleasant feeling. Really, the pleasant feeling is not the cause of the skill, nor is the skill the cause of the pleasant feeling, but the skill and the pleasant feeling both arise out of the same condition, namely, the diminished amount of resistance originating in habit.

Pleasure Succeeds Pain.—An unpleasant feeling is the concomitant of a stronger degree of resistance than is a pleasant feeling. So as the resistance decreases, the pleasant feeling takes the place of the unpleasant one. There is a common saying, that "It will feel good when it quits hurting," and indeed there is much truth in the saying. There is usually a distinctively pleasurable feeling accompanying the cessation of pain. The excessive magnitude of the impulse which has occasioned the great resistance accompanying the painful feeling has so modified the nervous arc that a smaller amount of current meets with less resistance than the same amount would have encountered had the nervous arc previously been traversed by a current of only ordinary strength.

Indifference.—In passing from a feeling of pleasure to one of pain, or from an unpleasant feeling to one of pleasantness, the feeling passes through a point of indifference, at which it is impossible to decide whether it is pleasant or unpleasant. The pleasure is most intense just before the point of indifference is reached. The sweeter anything is the more pleasant it tastes until it becomes too sweet, and then it is described as sickening. A faint odor is likely to be pleasant, but there seems to be no odor that is not capable of becoming unpleasant if it is intensified to a proper degree. There is truth in the saying, "Too much of a good thing."

Monotony.—An unpleasant feeling may diminish to the point of indifference, become pleasant, the pleasantness diminish until all feeling seems to evaporate, and

the feeling may be described as monotony. Monotony is not pain nor unpleasantness; it is rather a lack of pleasure. All acts tend to become monotonous as they become habitual, and take on the form of a reflex. By varying the action we throw new cells into the circuit, increase the resistance, and break up the monotony.

SIDELIGHTS

The sensation (feeling) of pain presupposes a reflex movement and an arrest of nervous conduction in the gray substance of the spinal marrow. It is this consciousness of inhibition in varying degrees that is felt by the consciousness as pain.—*Ribot, Psychology of the Emotions, p. 84.*

It (pain) probably supposes the subduing of a great resistance in the central nerve organs.—*Höffding, Psychology, p. 223.*

Where action is perfectly automatic (without resistance) feeling does not exist.—*Spencer, Psychology, Volume I, p. 478.*

Drugs such as chloroform in all probability produce their effect by increasing the resistance of the synapses.—*McDougall, Physiological Psychology, p. 47.*

Here we have the three familiar stages: the too easy, which does not excite any noticeable feeling; the moderately easy, which excites pleasure, and the too difficult, which excites unpleasantness. —*Külpe, Psychology, p. 255.*

Some part of the energy, then, of every stimulus is lost for sensation (feeling).—*Titchener, Outlines, p. 97.*

It is highly probable that in the state of surprise we have imperfect knowledge because we have too much sensation (feeling).—*Ribot, Psychology of Attention, p. 25.*

These several expositions, I think, make it clear that cognition and feeling, throughout all phases of their evolution, are at once antithetical and inseparable.—*Spencer, Psychology, Volume I, p. 478.*

The correlate of pleasantness or unpleasantness is the increase or decrease of the intensity of a previously constant current, if the increase or decrease is caused by a force acting at a point other than the point of stimulation.—*Max Meyer, Psychological Review, 1908, p. 307.*

Cognition and feeling must thus stand in inverse relation to each other. The more strongly one is manifested, the less strength at the command of the other.—*Höffding, Psychology, p. 98.*

Psychological technique and laboratory procedure have thus far proved inadequate in the realm of feelings.—*Charles Hughes Johnston, Psychological Bulletin, 1908, p. 76.*

It is tolerably plain that the relation of feeling to cognition cannot be expressed by any single formula.—*Stanley, Evolutionary Psychology of Feeling, p. 245.*

DEFINITIONS

Feeling.—Any kind of affective process, simple or complex, faint or vivid, pleasurable or painful.

Affective Process.—Any kind of mental process which does not give us knowledge, but whose most noticeable characteristic is pleasure or pain.

Sensibilities.—An old word used to mean the entire group of feelings.

Resistance.—As here used, it means the effect produced upon a nerve current by the arc through which it is transmitted.

Concomitant.—An invariable accompaniment.

Reciprocal.—A relation between two things which may be described by saying the more of the one the less of the other.

Indifference.—A high degree of feeling that marks the transition from painful to pleasurable, or from pleasurable to painful.

Monotony.—An absence of pleasurable or painful tone in any feeling. It is a condition in which little or no feeling is manifested.

CHAPTER XVI

Expression of Feeling

Expression of Feeling.—Whenever we experience any kind of feeling, there is some kind of muscular movement accompanying it which is called the expression. The muscles of the face are particularly expressive, and we can judge rather accurately by the expression of the face, what kind of feelings the person is experiencing. The facial expressions are produced by the contraction of the facial muscles and while we may be unable to describe the muscular contractions that produce the expressions, we are not likely to be mistaken about the kinds of feelings which they express.

Other Muscular Expressions.—Not only do the facial muscles express feeling, but other muscles of the body do the same. The heart may beat more rapidly when we experience one kind of feeling, and more slowly when we experience a different kind. The muscles that move the lungs fill them fuller and more frequently when we experience one kind of feeling, and are less vigorous in their action when we experience another kind. We can judge something of the feeling a person is experiencing by the very attitude of the body. The drooping shoulders, dragging walk, bowed head, are all indicative of a feeling that we may describe as dejection. But the upright carriage, vigorous steps, erect head, indicate a different feeling. Sometimes we can discover that a man is angry by the mere appearance of his back. We say that he is mad clear through.

Glandular Expressions.—Not only are muscles expressive of feeling, but the glands as well. The weeping of children is a most common expression of grief. Under the influence of the feeling of grief, the lachrymal glands are stimulated to secrete tears so abundantly that the secretion cannot be carried off in the usual channel, and the tears overflow the eyes. So the contemplation of an article of food that is much desired is likely to stimulate the salivary glands to an unusual secretion, and we say that our mouth waters. Occasionally in cases of excessive fright a cold sweat breaks out. The usual stimulus for the activity of the sudoriparous glands is heat; but, in case of fright, it is a different stimulus, and we experience the phenomenon of cold sweat. Occasionally, also, the inhibition of muscular or glandular activity is an expression of feeling. In some cases of fright, the heart seems almost to stop beating. When a speaker or singer becomes embarrassed, he is likely to experience a sensation of dryness in his mouth and throat, caused by the failure of the salivary or the mucous glands to secrete the usual amount.

Identical Conditions of Glandular and Muscular Expression.—Glands and muscles are both expressive of feeling. Under the proper conditions, and the influence of the proper feeling, every gland and every muscle in the body may be stimulated to activity and may express feeling. Glands and muscles are alike in the fact that they are stimulated to activity only by a nervous impulse that reaches them, without which they will not perform their proper function.

Common Theory.—The common theory about the expression of feeling is that we first experience the feeling and then express it. The feeling is experienced first and is the cause of the expression. No good reason can be

assigned upon this theory for the expression, and there is no necessary connection between the expression and the feeling. It is quite commonly believed that certain muscles, particularly those of the face, are designed from the first for the purpose of expression, and have no other function. Our common ideas of expression, and the words we use to describe it, including the word expression itself, are colored by this theory.

James Theory.—Another theory of expression is of so much importance and has exercised so much influence upon the study of psychology that it is necessary for us to study it carefully. This is known as the Lange-James theory, or, in this country at least, as the James theory. This theory asserts that the expression comes first and causes the feeling. First we weep, and then we experience the feeling of grief. We laugh, and after we laugh we are happy. In a dangerous situation, we first jump, or shriek, and only after the expression do we experience the feeling of fear.

Expression a Reflex.—According to Mr. James' theory, the muscular movement that is called the expression is purely a reflex, and has no mental antecedent nor accompaniment. An outside stimulus affects the organs connected with the muscles, and the muscles contract, thus producing the expression. It is the same kind of effect that is produced by striking the patella, causing the knee to jerk, or that is produced by the action of light upon the muscles of the iris, causing the pupil to contract or enlarge without any mental process, or the perception of the amount of light.

Origin of the Feeling.—Let us illustrate the process involved in the origination of the feeling by supposing that we are traveling along a lonesome road, or are in a haunted house, and see a ghost. Our hair may stand

on end. The muscle that tends to cause the hair to stand up perpendicularly to the skin is found at the root of every hair, but it is a vestigial muscle, and only under extraordinary circumstances is it made to contract. One of these extraordinary circumstances is the presence of extreme danger. The contraction is a reflex and entirely beyond the control of the will. When we experience the sensation of our hair rising, we then experience the feeling of fear. If we could interpret the order of occurrences, it might be represented by something like the following: "Hello. My hair is standing on end. There must be danger. I am scared."

Peripheral and Central Theories.—Mr. James' theory is susceptible of two interpretations. One is that it is the contraction of the muscle itself which is the cause of the feeling and determines what feeling shall be experienced. This interpretation of the theory makes of it a peripheral theory, or one in which the feeling is determined by the end organ of expression. The other interpretation assumes that the contraction of the expressive muscle establishes an impulse in the muscle itself which is transmitted to the brain, runs through some brain center, and that it is the transmission of this backward flowing impulse through the brain center that arouses the feeling and determines what it shall be. This interpretation makes of it a central theory, or one in which the existence of the feeling and the kind it shall be is determined by the brain center. Also, this interpretation would necessitate the existence of a brain center of feeling, in all probability different from the other centers that are traversed when an intellectual process is experienced.

Differences.—The important differences between the James theory and the common theory lie in the fact that

according to the James theory the expression comes first and causes the feeling. According to the common theory, the feeling comes first and causes the expression.

How Resistance Explains Expression.—The resistance theory asserts that feeling is the concomitant of the resistance which the nervous impulse encounters in passing through a nervous arc. If there is no resistance there is no feeling. But when a nervous impulse encounters resistance in a brain center it tends to spread out into the places and in the directions in which the least resistance is encountered. It is as if there were a pressure exerted upon the impulse in the brain center, or a tension which forces it out along the path of least resistance. We may compare it to the water in a canvas bag, when there is pressure exerted upon it. The water will be forced out through all the openings in the bag, and if the pressure is great enough, it will pass through the meshes of the canvas itself. The greater quantity will go through the larger openings, but some of it will go through every opening and through the interstices of the material of the bag.

Escapes Into Motor Centers.—When a nervous impulse thus encounters resistance, it tends to spread out into brain centers that are most easy of access. Generally, the motor centers will be most easily reached, since they are among the first that were organized, have been traversed most frequently, and have become associated by impulses passing between with almost every other brain center in the cerebrum. Then, too, the motor area is almost in the middle of the brain, and association fibers run to every part of the cerebral cortex. Hence it is that the motor centers are those that are likely to be most easy of access from every part of the brain, and the impulse under pressure flows readily over into them.

Relation of Feeling and Expression.—Now we can understand the true relation between feeling and its expression. The expression is not the cause of the feeling, nor is the feeling the cause of the expression, but both feeling and expression are similarly related to the same circumstance, that is, to the resistance which is encountered in the brain center. Without resistance, there would be neither feeling nor expression.

Expression and Feeling Synchronous.—The feeling does not precede the expression, as the common theory assumes, nor does the expression precede the feeling, as is asserted by the James theory. But feeling and expression occur at the same time, which is determined by the time that the resistance is encountered. It will be seen from this explanation that the resistance theory is a central theory, but does not necessitate the assumption of a separate series of feeling centers in the brain. Also it is clear that the relation between feeling and its expression will be a direct relation, the more intense the feeling the stronger will be the expression; and the weaker the feeling experienced, the less vigorous the expression will be. The concomitance in the variation, however, is not directly with each other, but directly between resistance and both feeling and expression; while it is only indirectly between feeling and expression, through the resistance.

First Argument for James' Theory.—Mr. James argues the case for his theory very skillfully. His arguments may all be reduced to three series, and we shall need to know how to interpret the facts he adduces in its favor according to the resistance theory. The first line of evidence is that direct observation shows that the expression occurs first and the feeling appears later. Thus nearly every person has been in some kind of

dangerous situation and did not experience the feeling of fear until after the danger had been escaped. Then the feeling appeared in great intensity, and the expression took on an exaggerated form.

Answer.—The answer to this argument is a direct denial of its universality. As many examples can be adduced in which the feeling occurred before the dangerous situation was encountered as can be shown in which the opposite relation prevailed. Many times persons have manifested great fear at the prospect of going into danger, when in the dangerous situation itself no fear was experienced. When two such series of contradictory experiences occur, it is evident that the theory that does not explain both cannot be true.

Resistance Explains Examples.—Both may be explained according to the resistance theory. In the cases in which no fear is experienced in the actual presence of danger, we may suppose that by the process of attention the impulse is directed through the brain center without resistance. When we study the phenomena of attention, we shall find that this is one of the effects that attention produces. But when we contemplate the situation afterward, or even before, we are not attending in such a way as to diminish the resistance, but rather we are increasing the resistance by our method of attention, and the feeling arises. We explain our lack of feeling by saying that we did not have time to be afraid, or we did not think about it.

Second Argument.—The second line of argument that is adduced by Mr. James is that the inhibition of the expression inhibits the feeling. If we repress the expression of any feeling, the feeling fails to manifest itself. If we stop to count ten, we do not become angry. If we refuse to run, or shriek, we do not become afraid. So

any feeling will fail to come into existence if we repress the expression.

Answer.—The answer to this argument is a direct denial. All of us can in some degree, and some of us in a high degree, repress the expression of feeling without destroying or greatly minimizing the feeling itself. It sometimes seems as if repressing the expression intensifies the feeling. This fact is expressed in the quotation from Höffding at the end of this chapter. Most women have experienced the relief of a "good cry" that diminishes, not increases, the feeling.

How Inhibit Expression.—Nearly all the examples that are adduced as illustrations of this argument of Mr. James find their explanation in one of two principles: When we stop to count ten, or think about something else, we are drawing away the nervous energy from the centers in which the resistance is accompanying the feeling, and are sending it through some other center, thus decreasing the resistance and inhibiting at once both the expression and the feeling. The other class of cases in which we repress the expression and at the same time the feeling, consists of those in which we direct the impulse through the brain center with little resistance by an act of attention. We may contemplate the circumstance directly, but attend to it in such a way that we decrease the resistance to such an extent that little feeling is experienced and little expression appears. We then say that we have reasoned ourselves out of the feeling.

No Decrease in Feeling.—But in cases in which the expression is inhibited while there is no decrease in feeling, the nervous impulse is prevented from entering the expression center by a process of attention. It may go into some other center or be completely repressed.

Third Argument.—The third line of evidence asserts that giving expression to a feeling induces the feeling. Here again the answer is a direct denial. All of us can in some degree, and some of us in a high degree, express feelings that we do not experience, and the smoothness of polite society largely depends upon our doing so. Mr. James says that actors experience the feelings which they portray, which is true of only some actors and certain instances of feelings. Nevertheless, the best way to portray accurately the expression of any particular feeling is to experience the feeling. Many persons can by a proper process of attention image a scene so vividly that there will be sufficient resistance to accompany the feeling appropriate to such a situation. When the resistance is encountered in the appropriate centers, the nervous impulse will overflow into the proper expression centers. The important process in inducing the feeling is to increase the resistance by the proper kind of attention. The expression is rather the sign that the feeling is being experienced, than a method by which the feeling is induced.

Origin of Particular Expressions.—The particular expression that belongs to any given feeling depends upon the resistance that is encountered in passing out of the brain center in which the resistance which accompanies the feeling is experienced. The question which we need to answer is how the connection between the center in which the resistance that accompanies the feeling is encountered and which for brevity we may call the feeling center, and the motor center, which similarly, with the serious risk of being misunderstood, we may call the expression center, has become such that a nervous impulse passes easily from one to the other. Ultimately it depends upon the structure of the brain and its nervous connections. In much the larger number of cases, the

causes for the particular connections are so obscure that we are compelled to describe them as fortuitous. Perhaps, primarily, all were of this kind. Many expressions are learned by imitation, which places the fortuitous origin of the expressive forms farther back in racial history. But no matter what the origin may have been, nearly all expressions become habitual, and become so thoroughly established and seem so ingrained and natural, that their fortuitous origin can scarcely be credited.

Useful Expressions.—But in a comparatively small class of cases, the expression itself is an advantageous action; and while its origin may have been fortuitous like any other variation, it has been preserved by the process of natural selection, and in all probability the nervous connection modified accordingly.

Expressions of Fear.—The expression of the feeling of fear is a good example of this very interesting class of expressions. Running away, or escaping from the dangerous proximity is the natural expression of the feeling, and this action undoubtedly preserves the lives of many individuals, and so is distinctly advantageous to the race. The shriek of fear is the expression commonly employed by children, and to a considerable extent by women, who are more likely to depend upon the assistance of another than to rely upon their own efforts to escape the danger. Any one who has heard the shriek of a child in fear has no occasion to be reminded how effective it is in summoning assistance. This expression is as advantageous to a weak or dependent individual as are the escaping movements to one who is accustomed to rely upon his own efforts.

Fear Paralysis.—But there is another expression of fear, also advantageous, which consists of a fear paralysis. This is most frequently seen in children, and in such

cases it often preserves the life of the child who without it would run into greater danger. It is the same expression, psychologically, as the feigning death in opossums and in many species of beetles and other insects.

Expressive Inhibitions.—The fear paralysis is another example of that kind of expression which we have already had occasion to notice in connection with the dry mouth as a sign of nervousness. Occasionally the inhibition of the proper activity of the muscle or gland is an expression of feeling. Grief may become so great as to prevent the shedding of tears. Under strong emotion the heart may beat more slowly and even miss a beat or two. Strong feeling is likely to interfere with the digestive processes, and persons have been known to faint from excessive emotion, nearly always of an unpleasant character.

Paralysis from Excessive Resistance.—The paralysis seems to be induced by the excessive resistance which breaks the circuit, preventing the impulse from passing. In such cases, it is doubtful if the feeling is so intense after the paralysis, as it was before the paralysis occurred.

Other Advantageous Expressions.—Darwin has pointed out many examples of this kind of useful and advantageous expressions. The crying of a child from hunger or pain, the shedding of tears, the contracting of the muscles around the eyelids in screaming, the lifting of the upper lip tending to expose the canine teeth in anger or disdain, with many more, are examples of expressions that come under this head.

SIDELIGHTS

The impulse overflows the cortex and becomes partially involved in the motor paths, since the muscles themselves reveal a trace of it. —*Morat, Physiology of the Nervous System, p. 518.*

* * * And on the principle of the radiation of nerve force, the glands would be stimulated.—*Darwin, Expression of the Emotions, p. 178.*

In adult life, also, very intense stimulations cannot be held within their ordinary channels, but become diffused through many courses. Note the contortions of the man undergoing torture at the hands of the dentist.—*Baldwin, Handbook, Feelings and the Will, p. 296.*

When an impression is accompanied by feeling, the aroused currents diffuse themselves freely over the brain, leading to a general agitation of the moving organs as well as affecting the viscera. —*Bain, Mind and Body, p. 52.*

Feeling makes a greater demand upon the nerve centers than cognition, and the consequent tension finds vent by distributing itself over a larger or smaller number of the remaining parts of the organism.—*Höffding, Psychology, p. 269.*

The Principle of the Direct Action of the Nervous System. It would be more correct to call this the overflowing excitation. This arises from the fact often observed in physiology that when a sensory excitation becomes too violent it diffuses itself all over the nervous system, and also to all the centrifugal paths whether motor or inhibitory.—*Morat, p. 405* (Derived from *Darwin, Expression of the Emotions*).

It is a sort of psychological law that the intensity of consciousness varies inversely as the intensity of the movements produced.—*Ribot, Psychology of the Emotions, p. 224.*

The concealment of a feeling may cause it to penetrate deeper into the nature of the individual.—*Höffding, Psychology, p. 332.*

Very often, as we all know, the checking of the free expression of the emotion tends to intensify rather than soften the emotion.—*Stanley, Evolutionary Psychology of Feeling, p. 361.*

Many emotional reactions are attributed by Spencer, Darwin and others to the extended diffusion of nervous energy throughout the nervous system, which many stimuli, particularly strong ones, cause.—*Major, Psychology, p. 328.*

DEFINITIONS

Expression of Feeling.—Some muscular movement, or glandular activity that accompanies the feeling, and may be taken as evidence that a particular feeling is being experienced.

Vestigial Muscle.—One that may sometime in the history of the race have been functional, but by variation or disuse has ceased to function and persists merely by the processes of heredity.

James's Theory.—A theory of feeling, or of the expression of feeling, which asserts that the expression appears before the feeling and causes it.

Peripheral Theory of Feeling.—Any kind of theory which assumes that the activity of the peripheral sense organ or muscle determines that there shall be a feeling and what the feeling shall be.

Central Theory of Feeling.—Any theory of feeling which asserts that the brain center determines that there shall be a feeling and what the feeling shall be.

CHAPTER XVII

The Properties of Feeling

Properties of Feeling.—Feelings differ from one another in several respects, and the means by which we distinguish them we may call their properties. We may discover three properties by means of which they are discriminated from one another.

Specific Character.—Feelings differ from each other in their specific character; by which we mean that they are of different kinds. We do not mistake a feeling of fear for a feeling of pity, and a feeling of anger is specifically different from a feeling of love. It is this specific difference that is indicated by the application of different names to the feelings.

Associated with Intellectual Processes.—It is impossible for us to understand the difference between feelings, unless we recognize that no feeling is ever experienced except in conjunction with some intellectual process. That intellectual process is always a perception, either of some object or of a relation.

Different Brain Centers Traversed.—No one will question the statement that whenever an intellectual process is experienced, a nervous impulse passes through some combination of cells in the brain. When an intellectual process of one kind is experienced, one combination of cells is traversed, and when a different intellectual process is experienced, a nervous impulse passes through a different combination. We are not able to state the reason for the association of particular mental processes

with particular combinations of cells, but the facts will be admitted by all psychologists.

Varies with Things Perceived.—We have seen that under proper conditions, resistance is encountered in a brain center whenever a nervous impulse of sufficient strength is transmitted through it. Whenever an impulse passes through some combination of cells, and accompanies the perception of a raging lion or an angry bull or some other dangerous animal, if the perception is clear, the nervous impulse strong, and the resistance great enough, we experience the feeling of fear. While, if the impulse passes through come combination of cells accompanying the perception of a starving mother with her family of little children, if the impulse is strong, the perception clear, and the resistance great enough we experience the feeling of pity.

Depends Upon the Brain Center.—The difference in the things that are seen accounts for the difference in the feelings that are experienced. Resistance encountered in one combination accompanies one feeling, while resistance encountered in another combination accompanies a different kind of feeling. Hence we may say that the specific difference in feelings depends upon the brain center in which the resistance is encountered.

What Brain Center Means.—When we use the term brain center in this connection we must understand that we mean, not a definitely circumscribed location in the brain, but the entire combination of cells that is traversed by an impulse. Also it must be understood that the same cell or group of cells may enter into many different combinations, and at different times belong to many different brain centers. Hence we shall expect to find that many feelings bear various degrees of relationship, and whole series shade into each other.

No Special Localization of Feelings.—With this understanding we shall avoid the implication that there is one brain center, or cortical area, in which the feelings are located. There is not one center for fear and another for veneration, but there are as many centers in which resistance accompanies the feeling of fear as there are things that we can be afraid of.

Number of Feelings.—As numerous as are the different kinds of feelings (Titchener suggests a list of more than a hundred), the number of intellectual processes must be indefinitely greater. This must be true, not only because of the fact that different intellectual processes are accompanied by the transmission of impulses through centers whose resistance accompanies the same kind of feeling, but because unless the resistance reaches a certain minimum which is difficult of determination, no feeling is experienced, while the concomitant intellectual processes may be very clear. Many intellectual processes are accompanied by no feeling.

Not Sharply Discriminated.—It is difficult as well as unprofitable to try to make sharp discriminations between feelings. The feelings shade into one another, and one feeling will be specifically related to another in exactly the proportion that the number of cells in the combination that offers resistance are identical with those in the combination whose resistance accompanies the second feeling.

Transformation of Feelings.—A feeling of one kind may change to a feeling of another kind even when we contemplate the same object. This is not in consequence of the difference in "attitude," whatever that may mean, but because of the change in the cells through which the nervous impulse is passing. A person who has never heard of a rattlesnake, and sees one for the first time,

is not in the least afraid of it. The cells through which the nervous impulse is passing are not those that have been associated with the feeling of fear. But a person who knows what a rattlesnake can do, when he sees a rattlesnake sees also his possible death; the suffering that may accompany the bite, the action of striking which the rattle precedes. All of these different combinations are traversed by the same impulse, and the resistance encountered in this entire combination accompanies a very different feeling from that which accompanies the resistance in the combination that gives merely a visual image of the snake.

Different Feelings With Same Perception.—But if the person becomes very familiar with rattlesnakes, has killed many of them and escaped many more; if rattlesnakes come to constitute an ever present element in the perceivable surroundings of the person, the feeling undergoes another change. Yet in all three cases, the supposition is that the same object is perceived, while really very different combinations of cells are traversed by the impulse.

Intensity.—Feelings differ from each other in still another respect. Not only is there specific difference, but there is a difference in intensity. There are weak feelings and strong feelings. We may experience a weak feeling of anger and a strong feeling of anger. We may pity a person much or little. But we may describe feelings as having different degrees of intensity even though they may differ in specific character. We may have a strong feeling of love and a weak feeling of contempt. Strong and weak are relative terms, and we may designate by them indefinite degrees of intensity which every one will recognize as having been experienced. How shall we account for this difference in intensity?

Depends Upon Amount of Resistance.—We have in the fact of resistance, an explanation of the various and varying intensity of feeling. The greater the resistance, the more intense will be the feeling, and the feeling will decrease as the resistance becomes less. We have in this fact an explanation of the decrease of feeling in habitual experience. No fact is better demonstrated in physiology than that habit tends to diminish resistance and the fact is generally recognized under the name of the law of neural habit. We have already seen that habit, or practice, decreases reaction time, and that the limit toward which practice tends to diminish it, is that of a reflex act. But no feeling accompanies a reflex, so we can readily understand that habit, repetition, practice may so diminish resistance that all feeling may disappear from it.

Intensity of Peripheral Experiences.—We have in this explanation of intensity an explanation also of the fact that an object, occurrence or an event that is observed directly is likely to be accompanied by a feeling of greater intensity than is one that is merely read about. If we should see a man run over by a street car and mangled out of all resemblance to humanity, the feeling accompanying such a perception would be so strong that we should characterize it only as a feeling of horror. But if we merely read about it in the morning papers, while we may be as certainly assured of the correctness of the account as if we had been present and witnessed it, the feeling that we should experience would be much less intense.

Feebleness of Central Experiences.—A peripherally initiated impulse is always stronger than a centrally initiated one. In case of our personal observation of the accident on the street car line, we have the whole situation presented to us by means of peripherally initiated

impulses, which are strong, and the percept is vivid, the accompanying impulses meeting with much resistance. But in the case of merely reading the account, the only peripherally initiated impulses are those that enable us to perceive the printed letters on the page, while the scene of the accident is pictured by means of centrally initiated impulses, which seldom approximate the intensity or encounter the same degree of resistance, as do the peripherally initiated.

Weakness of Remembered Feelings.—A dish of ice cream that is eaten is much more satisfying than is one that is merely thought about, because of the difference in the resistance encountered by the accompanying peripherally and centrally initiated impulses. It is difficult, if not almost impossible to remember, or reinstate, a feeling. We can remember, or re-experience a feeling only by reinstating the intellectual process that accompanied it, and if this is accomplished by means of a centrally initiated impulse, it is not likely ever to approximate the intensity and the resistance encountered by the previous peripherally initiated impulse.

Decrease of Intensity From Habit.—But let us suppose we should see a man run over by the street car every day, or that almost every hour in the day some event of this kind should occur within our observation. It would not be long until we should look upon it as a matter of course, and rather express astonishment when some person less accustomed to such gruesome sights should reprove us for being callous and hard-hearted. The degree of resistance and the intensity of feeling accompanying the first experience would become lessened by practice, custom, habit. Something of this kind must be considered to occur in case of soldiers who have participated in many battles. Physicians undergo the same

kind of experience in their dealing with examples of suffering, and the same kind of change is observed in the case of persons whose duty it is to slaughter animals for market.

Other Conditions of Decreased Intensity.—Since the amount of resistance is determined by the strength of the impulse as well as by the condition of the brain center, anything that modifies the amount of nervous energy will modify the resistance and the intensity of the concomitant feeling. If the amount of nervous energy be decreased in any way, by narcotics, impure air, disease, starvation, or lack of blood supply, the resulting feeling will be decreased in the same proportion. This will enable us to understand why in sleep, or as the result of a dose of morphine, the feeling is lessened.

Intensity Modified by Attention.—Besides these factors, the degrees of resistance and its concomitant intensity of feeling may be increased or decreased, although both the brain center and the amount of nervous energy remain the same, by a process of attention, whose mechanism we shall study in a subsequent chapter.

Tone.—A third property of feeling is tone, by which we mean its pleasurable or painful character. This quality is of so much importance in the life of the individual that many writers on psychology have regarded pleasure and pain as constituting the feeling itself. Some have regarded pain and pleasure as qualities of the intellectual sensation, rather than of the affective process, feeling. However, we shall see that pain and pleasure are associated not with the amount of nervous energy that is transmitted through the brain center, but with the amount which is stopped out by resistance.

Differ Quantitatively.—Pain and pleasure are not specifically different from each other, but differ quan-

titatively rather than qualitatively. Pleasure may pass into pain, and pain into pleasure, without having the specific character of the feeling altered. Or, perhaps for the sake of accuracy, we ought to say that a feeling of a painful tone may pass into a feeling of the same specific character having a pleasurable tone. We experience a feeling of a painful tone when our hands are cold. When we come near a hot stove the feeling of warmth has a pleasurable tone; but as the hands become warmer, the feeling may change to one of a painful tone. The odor of flowers is pleasant, but if the perfume is intensified, the accompanying feeling will, with nearly every odor, become painful.

Change of Tone.—Up to a certain point, the greater the intensity the more pleasant the tone; and beyond that point, an increase in intensity changes it to pain. We can understand that by varying the intensity we may cause a feeling having a pleasant tone to change to one having a painful tone, and conversely, we may cause a feeling having a painful tone to change to one having a pleasant tone.

Change of Tone from Habit.—A feeling having a painful tone may change to one having a pleasant tone by varying the resistance, either through habit, attention, or by diminishing the amount of nervous energy so as to produce less resistance and its concomitant feeling. Washing dishes is with many girls a disagreeable occupation, as is the weeding of the onion bed to the small boy. But by continued repetition, the feeling becomes diminished in consequence of the diminished resistance incident to the habitual act, and the feeling becomes less unpleasant, even if not positively pleasurable. It is not often that an occupation pleasant in the beginning remains continuously so. It becomes, not painful,

perhaps, but rather monotonous, and ceases to furnish pleasure.

Effect of Difference in Tone.—We may say in general that those actions which are accompanied by feelings having a painful tone are injurious, and those that are accompanied by feelings having a pleasurable tone are beneficial; or, painful feelings are injurious, and pleasurable feelings are beneficial; or, still more briefly and less accurately, that pain is injurious and pleasure is beneficial.

Origin of Pain.—Any activity is accompanied by a feeling having a painful tone if the destruction of tissue in the active organ, nervous, muscular or glandular, goes on at a more rapid rate than it can be restored. When the destruction of tissue is not greater than can be restored as rapidly as it is used up, pain will not ensue. Whenever a nervous impulse encounters great resistance, we have a condition in which there is a rapid destruction of tissue in nerve and brain. We cannot have great resistance without the liberation of much nervous energy, and this implies rapid oxidation of tissue.

Excessive Intensity Painful.—It seems that pain arises whenever the activity of any organ is of such a nature that its continuation will prove injurious to the organ exercised. The feeling of fatigue is a painful feeling, and the actions that give rise to it are so excessive as to be injurious if persisted in. It is pleasant to see the sunlight, but to look directly at the sun engenders a feeling of such intensity as to be painful, and is injurious to the eyesight.

Mental Pain Socially Injurious.—The illustrations that have been employed have all been of that kind which is called physical pain, but the same thing is true of other kinds of pain as well. When the action is of such a kind

as to be injurious to the social organism, it is likely to be accompanied by a feeling having a painful tone, examples of which may be found in the feelings that have been called conscience, shame, remorse. An action that is injurious to racial propagation is likely also to be accompanied by mental feelings having a painful tone. So we may say that in general, any action that is injurious to the physical structure or the social organism is likely to be accompanied by a feeling having a painful tone.

Epicureanism.—The statement that pain is injurious is misleading if not properly understood. The correct form of statement is that those actions which are accompanied by feelings having a painful tone are injurious, and those actions accompanied by feelings having a pleasurable tone are beneficial. Now it seems as if we have a very satisfactory theory of life. In order to do the things that are beneficial, we need to do those things that are pleasant and avoid those that are unpleasant. We are thus landed into the philosophical system of the Epicureans.

Apparent Exceptions.—But there are so many examples of a contrary nature that we are inclined to question the philosophical soundness of the doctrine. If I should never do anything unpleasant, why am I advised to take quinine, or other equally distasteful medicine? Why am I told that the things I like to eat best are nearly always the things that are most likely to be injurious to my health? Why am I advised to get up early in the morning, and to take exercise when I would so much rather not? Why am I advised to study in school the things that I like least, or why should I find it necessary to go to school at all, when I would so much rather play?

How Explained.—The answer is easy. If we were perfectly adjusted to the environment in which we live,

the rule would hold good in every instance. The things that are accompanied by pleasant feelings would always be beneficial, and those that are injurious would invariably be accompanied by unpleasant feelings. But we are never perfectly adjusted to our environment, and never can be completely so. Our environment changes, children grow, improvements are made in methods of work, habits of living, and social ideals. Our ancestors lived in a different climate and in different surroundings from what we do, and our whole hereditary fabric must be readjusted to the changed conditions. Our environment changes, and our perfect adjustment is destroyed. It is in the process of readjustment that the beneficial action is accompanied by an unpleasant feeling. Any process that is now unpleasant would ultimately become pleasant if only those who performed the unpleasant act survived and left descendants; while those who were prevented from performing it by its unpleasantness died and left no descendants in consequence.

Pain and Pleasure Both Beneficial.—Not only is pain in itself not injurious, but both pain and pleasure are alike beneficial. Pain is beneficial because in consequence of it we are induced to discontinue an injurious action. Pleasure is beneficial, because by it we are induced to perform the things that are advantageous to ourselves as individuals and to the community or the race. The painful feeling of hunger leads us to eat, and the pleasurable tone of the feeling accompanying the process of eating, contributes to the same result. Both pain of hunger and pleasure of eating conspire to induce us to eat, and when we realize that to eat is the first condition of living, we shall see that the process is not too well guarded by both pain and pleasure. In animals born like Mr. Hodge's puppies that refused to eat, having the fibres

of the brain non-medullated, no eating instinct being developed at birth, and no nervous organization that led to it, death was of course inevitable. They were described by Mr. Hodge as non-viable.

Advantage of Pain.—Pain is a symptom of disease. It is a warning. As Dr. Woods Hutchinson calls it, it is the great danger signal of nature. The business of treatment is to cure the disease, not merely to mitigate the pain. If the pain is not relieved by the cure of the disease, but is mitigated by the use of morphine or other narcotic drugs, or even by faith cure, or Christian Science, the relief of the pain is an evil rather than a good.

Non-Painful Diseases Dangerous.—Some diseases, of which consumption may be taken as a type, are exceedingly dangerous, merely because in their early stages they are accompanied by no pain. More persons die of consumption every year in the United States than of any other disease, and yet in its early stages it is one of the most easily curable of diseases. If it were accompanied in its early stages by as much pain as a sore finger, no one would in all probability die of consumption.

Feelings of Constant Tone.—Pain and pleasure have been described as arising out of different degrees of intensity of the same feeling. Any feeling may have a painful tone or a pleasurable tone, depending upon the intensity of the feeling and its correlative resistance in the brain center. While in general this is true, it is possible that a modification of it is necessary in case of some of the most important activities. It is possible that some actions and some conditions are always painful, no matter how little the intensity may be. It is doubtful if the feeling of hunger is ever pleasant, and possibly the feeling of fear may be the same. These

feelings are of so much importance to the preservation of the individual that it would be unsafe to permit any degree of pleasure to exist in them.

Constantly Pleasant.—Other feelings may be as consistently pleasant, as some of the race perpetuating feelings. It seems as if the activities of such tremendous importance cannot be trusted to the judgment of the individual; or rather, that those individuals and those races in which certain important feelings always had these particular tones were the races and the individuals best adapted to leave the largest number of descendants, and whose descendants had the best chance of surviving. Such examples, however, furnish no grounds for postulating a separate apparatus for pleasure and pain. They are brought directly under the laws of feeling, and explained by the resistance that is encountered in the brain centers traversed by the appropriate impulses.

Pain Not a Universal Device.—We are so much accustomed to think of pleasure and pain as incentives to our actions that we can scarcely conceive that other creatures may not be actuated by the same devices. But to assume that pleasure and pain are universal in the animal kingdom, and still more in the plant world, would not be justified by anything that we know. We are inclined to attribute the squirming of an earthworm when it is cut in two to the fact that it feels pain, but there is really no more reason for considering the squirming a manifestation of pain than of pleasure. A beheaded hen is moved to violent action, but we can scarcely see how a hen with her head cut off can experience pain, or even pleasure. So the squirming of an earthworm may be an expression corresponding to our violent exertion of laughter, so far as we can discover. The action of a sensitive plant is not different from that

of many animals whose actions we call expressions of pain, yet no one believes that the sensitive plant experiences pain. Although insects are highly organized creatures, it is doubtful if they are protected by the device of pain. At least, it is exceedingly difficult to prove that they are.

SIDELIGHTS

The differences among feelings we must try to explain by the different cognitive elements that may be combined with them.—*Höffding, Psychology, p. 222.*

It is therefore an error, though common to most psychologists, to consider pleasure and pain as fundamental elements of the affective consciousness. They are only marks. The foundation is elsewhere. What would be said of a doctor who confused the symptoms of a disease with its essential nature?—*Ribot, Psychology of the Emotions, p. 32.*

By tone of sensation (feeling) is meant the feeling of pain or pleasure that accompanies it.—*Baldwin, Handbook, Feelings and Will, p. 114.*

The agreeableness or disagreeableness of impressions, or states of consciousness—that emotional coloring or tone that makes them pleasant or distasteful—should be regarded rather as psychical qualities of sensation (feeling) than as separate and distinct elements.—*Lloyd Morgan, Comparative Psychology, p. 140.*

Pain is any sensation raised above a certain intensity.—*Woods Hutchinson, Gospel According to Darwin, p. 213.*

But neither pain spots on the skin, nor a stimulus especially adapted in quality to cause sensations of pain have been shown to exist.—*Ziehen, Physiological Psychology, p. 139.*

From this it follows that pain requires no special apparatus for its production. There is no organ of special pain sense, and there are no special conductors of pain. There is no system that properly belongs to it, no region in the cerebral cortex that is allotted to it. —*Morat, Physiology of the Nervous System, p. 405.*

The presence of pain is distressing, its absence is fatal.—*Woods Hutchinson, Gospel According to Darwin, p. 13.*

DEFINITIONS

Property of Feeling.—A difference in feelings by means of which we distinguish one from another.

Specific Character.—That property of feeling which is expressed by giving feelings different names.

Intensity.—That property of feeling which we describe by saying that the feeling is strong or weak.

Tone.—That property of feeling that is described as pleasure or pain.

Epicurean.—One of the followers of the philosopher Epicurus who lived in Greece, about 320 B. C., and taught that the obtaining of pleasure constituted the highest good.

CHAPTER XVIII

Classification of Feelings

Purpose of Classification.—There can be only two purposes in the classification of a series of objects or processes; one is that of enabling us to remember the series more easily. When such is the purpose, the basis of classification is likely to be some purely accidental circumstance, and the resulting classification is not likely to possess a high order of merit. The second purpose is to show forth some relation that would not otherwise be discovered. Such a classification is likely to have for its basis some important character, and the classification will exhibit the natural relations between the objects classified, manifesting their nature more fully than would be possible without it.

Natural Classification of Feelings.—As there is but one natural classification among animals and plants, which shows forth their relation by descent, so there is but one natural classification of the feelings, and that is one which manifests the relations among the feelings according to the functions that they perform in the life of the individual and the race, and the manner in which they have originated.

A General Principle.—One general principle must be recognized in the study of the feelings, that is, that every feeling has now, or had in the comparatively recent past, some advantageous function to perform in the life of the race or the individual. If any feeling that is now experienced should prove to be injurious to the individual or

to the race through the individual, that feeling would ultimately disappear as a human characteristic, in consequence of the elimination of the individuals in whom such feelings manifested themselves in an injurious manner. So a feeling that has proved itself advantageous to the individual, or to the race through the individual, has become fixed as a human characteristic by means of the advantage that the individuals who experienced the feeling had over the individuals who did not possess it.

Natural Selection in Feelings.—This is the ordinary law of natural selection, and while its operation is difficult to trace in mental processes, its efficiency has been manifested in so many directions that there is no hesitation in making this application of it to psychological processes, especially in the domain of the feelings.

Two Primary Divisions.—In the development of every species of animals and plants, some means must be employed to secure the preservation of the individual and the propagation of the species. These are the two fundamental processes, and since in the human race the feelings largely determine the actions that secure these two results, it is possible to reduce all feelings to two great classes, one class being those feelings that accompany actions leading to the preservation of the individual, and the other the feelings that accompany actions leading to the propagation of the species.

The Two Divisions Fundamental.—These two groups of feelings are basic, and it is impossible to conceive how without them, the race could have survived, or have come to constitute a factor in the living world. No system of philosophy can ever hope to prove satisfactory as an explanation of human events that does not see all human actions springing out of these two great functions. Hence we may expect the primary classification of feel-

ings to be into two groups, the self-preserving and the race perpetuating.

A Third Principle.—But early in the history of the race, another principle came into operation. This is expressed in the gregarious principle by which human beings came to live in herds, or in society. The social organization has had such a tremendous influence in increasing the power of the individual, leading to the greater efficiency of the self-preserving activities, and multiplying the number of individuals that constitute the species, that in periods of time comparatively recent, the function of social organization has become of almost equal importance with the self-preserving function. Hence it is that, while the feelings that lead to actions which maintain the social functions have been derived from the self-preserving group, we must set them off by themselves as an independent group yet showing traces of their self-preserving origin.

The Three Groups of Feelings.—Since there are three important activities in the life of the race, we shall recognize that there are three great groups of feelings that correspond to these functions. The three groups are the self-preserving feelings, which are called by Mr. Spencer, the egoistic; the community-preserving feelings, which correspond very nearly to Mr. Spencer's group of altruistic; and the race-perpetuating, which include, without having the same limitations, Mr. Spencer's group of the ego-altruistic.

Self-Preserving Feelings.—The self-preserving feelings, having once been named, need no definition nor description. They constitute a large group of feelings that accompany actions leading to the preservation of the individual. Nearly all the feelings that accompany the physical functions belong to this type. The feeling

of hunger leads to the preservation of the individual by inducing actions that procure food. The pleasure derived from eating is of the same kind. Thirst, nausea, and fatigue belong to this group. The advantage of fatigue is very evident. Excessive activity of the muscle leads to destruction of tissue more rapidly than it can be replaced, and danger of permanent injury arises. But the feeling of fatigue accompanying the increased resistance in the muscular center necessitates the cessation of activity.

Self-Preserving Fear.—Not all self-preserving feelings are related to the physical functions. A good example is the feeling of fear. We have seen in a previous chapter that the various expressions of this feeling are actions, each of which in its appropriate situation tends to preserve the life of the individual. The shriek of the child, the flight of the man, the fear paralysis of the child or the man, each in its own situation may preserve him.

Children's Feelings Self-Preserving.—The self-preserving feelings are especially dominant in the life of the little child. His only business is to live, and he makes everything else subservient to that purpose. There is no room in the constitution of the little child for feelings of self-abnegation. He has no shame, modesty, reverence, gratitude, remorse, sympathy or pity. The doctrine of total depravity is inevitable if we fail to take into account the function of the feelings that a natural classification discloses.

Community-Preserving Feelings.—The second great group of feelings are the community-preserving, or altruistic feelings. The name community-preserving is much to be preferred, since it renders superfluous any explanation or definition of the group. While this group

has been developed out of the self-preserving feelings, it was split off from them very early in the history of the race, when it adopted the gregarious habit of living. It is probable that the community-preserving feelings exercised little influence upon the actions of men before the time that is known to anthropologists as the period of middle barbarism. We should not expect any great strength in the community-preserving feelings until there was a community to preserve, and the community would in all probability develop coincidently with the growth of the appropriate feelings.

Developed Out of Self-Preserving.—It is possible to show that the community-preserving feelings have been developed out of the self-preserving, and that they are in their origin the same. Hence it is not at all a matter of surprise to us that so much ingenuity has been expended in showing that altruism and egoism are at bottom one and the same thing. The person who preserves and benefits himself at the same time benefits the community of which he forms a part by furnishing it with a more efficient member. So the person who does something to benefit the community is at the same time benefiting himself, since he constitutes a part of the community to whom the benefit of his action accrues.

Community-Preserving Actions.—Any action that directly results in benefit to some one else is properly a community-preserving act, and the feelings that are appropriate to it are community preserving feelings. We fail to recognize it as such in many cases, because by habit the feeling has largely disappeared from most of the community-preserving actions that we do. The man who shovels coal into another man's cellar window is engaged in an altruistic act, and equally so is the man who puts up a sign in front of his store to let persons

know where they can buy the kind of goods that they desire to purchase.

Not Necessarily Sacrificial.—Such actions are not commonly recognized as altruistic, because our content for the word is altogether too narrow and perverted. As habitually employed, it includes something of the idea of sacrifice and painful tone in the feeling that accompanies the altruistic action. Such is not a proper meaning for the word, and the way in which such a perverted meaning came to be applied to it furnishes a most interesting chapter in the history of philosophical doctrine.

Community-Preserving Feelings Moral.— To this great group of community-preserving feelings belong all the feelings that we call moral. Justice, truth, integrity are all of them necessary for the preservation of the community, and the community is strong in exactly the proportion that these feelings dominate the actions of all its members.

Courage.—But there are other feelings belonging to this group whose position is less readily seen. Courage is the great virtue, and in fact is the mother of all the others. Courage is a community-preserving feeling, and finds its utility in the benefit it confers upon the community. Courage is the feeling that leads a man to go into the army and fight, even though he knows that he will be killed. In this way it comes directly into conflict with fear, which is a self-preserving feeling. Courage, not hope, is the antithesis of fear.

How Benefit the Community.—The individual who goes into battle and is killed, benefits the community, not directly by getting himself killed, although all of us have known men who we have reason to believe could benefit the community more by getting themselves killed than they could in any other way. But the man who goes to

war and fights the enemies of his community, even though he is killed himself, preserves the community for which he fights.

Not the Death of the Individual.—The death of the individual, especially one who has courage and the virtues that properly associate themselves with it, is directly an injury to the community. But in case that the existence of the community is threatened, it is advantageous to set aside a portion of the community, even one-tenth of its members, to fight and be killed, if thereby the safety and continued existence of the community with the other nine-tenths of its members is assured. Hence it follows that courage is a community-preserving, moral feeling.

Malevolent Feelings.—Among the community-preserving feelings we must class some that at first glance appear to be directly contradictory to the definition implied in the word community-preserving. Here belong such feelings as anger, hate and revenge. These are the feelings that are sometimes called the malevolent group. It appears to be almost a paradox to class them with the community-preserving, or altruistic group, because to our common thought it appears that they are community-destroying feelings.

How Explained.—But we must look for a justification of our grouping to the function that they have had in racial history when they became established by the process of natural selection. In certain stages of society which we have called savage, it is universally regarded as a moral obligation to take revenge for the killing of a kinsman or fellow tribesman. The killer himself, or some member of the killer's family must be killed, and a relative of the murdered man who does not seek revenge is considered immoral, and unworthy fellowship

in his tribe. Even now in warfare it is considered necessary to stir up hatred and revenge toward the members of the nation with whom we are at war. It is necessary to "fire the national heart." This induces enlistment in the army, prevents desertion, and makes better fighters. An army disintegrates if its soldiers become friendly with the soldiers of the enemy.

When Moral.—It is perfectly allowable to hate an enemy in warfare, and to kill him if we can. A soldier must kill, take human life. That is what he is hired for, and the feelings appropriate to such actions, and which lead to killing, are moral, virtuous, and tend to preserve the community.

When Immoral.—These feelings have their appropriate function when they are directed toward the enemies of the community, and when so directed tend to preserve it. They receive their reprehensible character when, instead of being directed toward the enemies of the community, they are directed towards the members of the same community. Then they become immoral and detrimental to the community itself. Since warfare has ceased to be a universal and constant occupation, these feelings have largely lost their appropriate character and persist rather as vestigial feelings, than as feelings whose functions are still important. They have ceased to be regarded as moral, and have come to be considered immoral, which fact in itself is an indication of their vestigial character.

Among Whom Best Exemplified.—We find anger, hate and revenge best exemplified in those members of the community who are least developed; among the uneducated and the lowest stratum of society; among the near-criminals. They are least exemplified among the better classes of persons in the community, and when

they are manifested, they are never boasted about, but concealed with shame. So when we find anger and revenge exhibited by little children, we recognize these feelings as an indication of an undeveloped condition, and perhaps as the bringing forward of a tendency that is becoming vestigial, and being dropped out of the life of the race as a characteristic of a human being.

Sympathy, Pity, Charity.—We recognize pity, sympathy and charity as the best examples of community-preserving feelings, and we can readily understand that they benefit the community by preserving many of its members who would otherwise be unable to preserve themselves. They are the best examples of the moral virtues, but it is perfectly possible that they might come to be considered immoral, and to occupy the same position in the estimation of the community generally that is now held by anger, hate and revenge.

May Become Immoral.—We know that there are paupers, criminals and hopelessly insane persons in every community who must be supported and cared for by the work of other members. They constitute a weakness to the community, detracting from its strength and ability to accomplish what it otherwise would be able to do. We can see what the effect is if we should imagine the defective and dependent classes to become very much larger than they are at present and to continue to be supported by the community. The feelings of pity, sympathy and charity would then constitute a source of great weakness to the community, and tending to destroy it, would without any doubt come to be regarded as immoral. Even now we are taught that indiscriminate charity giving to beggars on the street is not a virtue, and should never be practiced. So it is not justice to allow defectives to marry and perpetuate their kind.

Race-Perpetuating Feelings.—The race perpetuating feelings constitute a third group. They are fundamental in the development of the race, and have the same basic position as do the self-preserving feelings. They are even more fundamental than are the community-preserving feelings, and even more powerful in leading to action, though their range is more circumscribed.

Incident to Family Life.—The race-perpetuating feelings are such as are incident to the rearing of children, and the propagation of the species. They are those that are especially incident to the family life, such as the love of a man for his wife, or wife for her husband, present or prospective; of parents for children, or a brother for a sister, or better, for somebody else's sister.

Mother Love.—The best example of race-perpetuating feelings is perhaps that of mother love. This is a feeling of such intensity that it will overcome almost any other kind. A woman is likely to be influenced strongly by the feeling of fear, a self-preserving feeling. But the influence of mother love will completely annihilate the self-preserving feeling, and make of the mother an embodiment of courage. A parent can be injured in no other way so severely as through his child, and nearly any parent will, if necessary, preserve the life of the child at the sacrifice of his own.

Late in Appearing.—The race-perpetuating feelings are rather late in making their appearance, and scarcely manifest themselves in typical forms before the age of adolescence. Then they assume a dominant importance in the life of the individual.

Religious Feelings Race-Perpetuating.— The three groups of feelings that we have described are delimited from each other according to the functions that they have performed in the development of the race. The religious

feelings constitute a group in a different system of classification, and are separated from other groups of feelings by the object toward which they are directed. Much the larger number of religious feelings will find their place in the group of the race-perpetuating feelings, and are derived from them. This is shown by the fact that the important religious experiences occur nearly coincidently with the development of the race-perpetuating feelings, and in connection with the oncoming of adolescence. The terms that are employed in religious life are those particularly appropriate to family matters. Father, son, bride of Christ, born again, brother, sister, are particularly noticeable. Similarly, the hope that religion holds out of a reunion of the family that has been separated by death is the most convincing appeal that can be made to believe in some of the most essential religious doctrines, such as life after death and immortality.

Religious Feelings of the Self-Preserving Group.—But other religious feelings belong to the self-preserving group. These are the selfish feelings, and the belief in religion as a means of obtaining assistance in one's career, or in obtaining anything whatever that is ardently desired, as well as the hope of continuing existence and escaping future punishment. All feelings that relate to these activities and are classed as religious belong to the self-preserving or selfish group.

Religious Feelings of the Community-Preserving Group.—But other feelings are designated as religious which are allied to the community-preserving group. In so far as religion enters into the development of morality, the concomitant feelings belong to the community-preserving group. It will be recognized that there is a wide diversity among different persons, religions and races concerning the feelings that may be called religious, but

that there is no necessity for establishing a separate group of religious feelings, since all of them fall naturally into one or the other of the three groups already established.

Esthetic Feelings.—It is quite common to describe a fourth group of feelings called the esthetic. Esthetic feelings are those which accompany the perception of the beautiful or the ugly. But when we undertake to decide what constitutes the beautiful or the ugly, we are compelled to rely upon the feelings that are awakened, or we must adopt a conventional standard.

Pseudo-Esthetic.—Some things are judged to be beautiful wholly because a conventional standard has been established, and we have been taught to call them beautiful. The things adjudged beautiful are called so because they conform to this standard, not because we ourselves experience pleasure from their perception, independently of the standard. Such feelings may be called pseudo-esthetic. We may experience much pleasure from owning and wearing a large diamond, but when we learn that instead of its being a diamond it is merely glass, our pleasure is very much diminished. We may be unable to discover the difference ourselves between the real diamond and the imitation, and our pleasure ought to be as great in the one case as in the other. But it is not, and consequently the feeling may be described as pseudo-esthetic. Our judgment of the beautiful in this case turns upon the opinion of other persons, and consequently we may group such pseudo-esthetic feelings among the community-preserving.

Esthetic Race-Perpetuating Feelings.—But we judge other things to be beautiful that do not conform at all to the standard established by other persons. No one ever heard of a mother who was willing to accept the

judgment of other persons in general upon the beauty of her children. Nor does a lover experience esthetic feelings in accordance with the judgment of the community concerning the beauty of his sweetheart. Such feelings are not pseudo-esthetic, nor do they belong to the community-preserving group. They are excellent illustrations of race-perpetuating feelings.

Esthetic Self-Preserving Feelings.—There are two kinds of esthetic feelings that belong to the self-preserving group. One is that kind of feeling that is manifested in perceiving such objects as the rainbow, or a magnificent sunset, or any other experience that accompanies pleasure derived from a mere exercise of the senses. This is an example of the purest esthetic feeling and does not depend upon any conventional standard, nor the judgment of other persons.

Esthetic Adaptations.—A second kind of esthetic feelings that belong to the self-preserving group is that accompanying the judgment of beauty in anything that performs its function admirably. The delicate mechanism of a watch, or other piece of machinery, the admirable adaptations seen in a flower or the mechanism of an animal, the adjustment of the seasons and method of distributing the rainfall may all of them awaken esthetic feelings, and they are of such a nature that we may group them with the self-preserving. Many persons refuse to call them esthetic, but personally it appears to the writer that they are excellent examples.

SIDELIGHTS

It is evident that in a certain stage of development anger must have been a most protective reaction—but that nowadays, among the highly civilized, it must be detrimental.—*H. R. Marshall, Pain, Pleasure and Aesthetics, p. 295.*

Instincts (better feelings) fall naturally into three great classes: First, those instincts that tend to bring about the persistence of individual life; second, those that result in actions favoring the persistence of the species; third, those that tend to bring about the persistence of certain aggregates of individuals which we call social groups.—*H. R. Marshall, Instinct and Reason, p. 160.*

This conclusion agrees well with the belief that the so-called moral sense is aboriginally derived from the social instincts, for both relate at first to the community (exclusively).—*Darwin, Descent of Man. p. 135.*

According to Adam Smith, "Self-preservation and the propagation of the species are the great ends which nature seems to have proposed in the formation of all animals."—*Baldwin's Dictionary, Volume II, p. 512, Art, Self-Preservation.*

Nevertheless, the first foundation, or origin of the moral sense lies in the social instincts, including sympathy, and these instincts were primarily gained as in the case of the lower animals, through natural selection.—*Darwin, Descent of Man, p. 700.*

DEFINITIONS

Classification.—An arrangement of a number of objects in series according to the presence or absence of certain characteristics in them.

Natural Selection.—A principle by which those animals or plants which present some characteristic that adapts them to their situation are preserved (or selected) while those that do not possess the advantageous character die off and leave no descendants. Ultimately it happens that all the animals or plants that survive possess the adapting character.

Self-Preserving Feelings.—Those that accompany actions that tend to preserve the individual. Called also egoistic, or selfish feelings.

Community-Preserving Feelings.—Those feelings that accompany actions that tend to benefit or preserve the community. Called also the altruistic, and moral feelings.

Race-Perpetuating Feelings.—Those feelings that accompany actions tending to propagate the species and perpetuate the race.

Esthetic Feelings.—Those feelings that accompany the perception of anything that is adjudged to be beautiful or ugly.

CHAPTER XIX

Consciousness

Consciousness.—The entire matter of consciousness is in a more confused and disordered state than that of almost any other division of psychology. The confusion arises largely from the use of the word consciousness in two distinct senses, with a strong tendency to adopt the one that is least to be commended. The first use of the word means a knowledge of our own mental states and processes that are in progress at any particular time. This is sometimes described by employing the word awareness. In the terms of the old Psychology, consciousness was defined as the power the mind has to know its own states and actions. It gave us knowledge of our own mental states and processes.

Awareness.—We no longer describe mental processes as powers, and by consciousness we mean the knowledge of our mental processes; or we may mean the process by which our own mental states become known; or, the property of a mental process by which it is known to us. Either of these descriptions is indicated by the word awareness to discriminate it from another use of the term.

Unconsciousness, Loss of Awareness.—This is the common meaning of the word. When we speak of losing consciousness, we mean that we cease to be aware of the mental processes that are going on. We are unconscious when we are asleep, and when we awaken we become conscious. Chloroform brings on a condition of

unconsciousness, and equally effective in producing the same result is a blow on the head. Unconsciousness may be produced in many ways, and the difference between consciousness and unconsciousness is always the same.

Consciousness as a Synonym for Mind.—But another content of the word consciousness has come into very general use among psychologists, and by it is meant any mental process that can be experienced. It is used as a synonym for mind. Any mental process is a state of consciousness, and there can be no mental process that is not a conscious state. This is one form of the statement, and another form which is intended to mean the same thing is that there can be no mental process that is not attended with consciousness. In fact, the first statement that any mental process is a state of consciousness grows out of the second that every mental process is attended by consciousness, or is a conscious state. It will be seen when we compare these two statements that there is involved in them a begging of the question, or an assúmption of the thing that we undertake to prove.

Not a Proper Use of the Word.—It would be equally possible to prove that every mental process is accompanied by feeling, and therefore every mental process is a state of feeling; or, that every mental process is accompanied by some muscular movement, and therefore every mental process is a state of muscular contraction; or, that every mental process is accompanied by a process of attention, and therefore every mental process is a state of attention; or, that every mental process is a conative condition, and therefore every mental process is a state of will. Any one of these statements has the same kind of justification that is shown by the definition that a mental process is a state of consciousness.

Unconscious Not Mental.—The second meaning

of the word grows out of the arbitrary doctrine that no unconscious process can be mental, and that such unconscious state does not constitute a proper subject for discussion in psychology. Those who employ the second meaning of the word assert that there is no difference between a sensation and the consciousness of a sensation, and that an unconscious mental process is a contradiction in terms.

Consciousness Not Necessary to a Mental Act.—Let us note in the first place that consciousness is not necessary to a mental act. Consciousness is most intense when the mental processes are most imperfect and hesitant. When we are learning to skate or play the piano, or to whet a razor, we are most intensely conscious of our actions. Even if our actions are not physical but mental, as in making a difficult calculation in arithmetic, we are intensely conscious of the steps that must be taken in learning it. But as we become familiar with the process, and acquire skill in doing it, the intensity of consciousness diminishes until when we have attained the highest degree of skill, it seems almost to have disappeared. This is one of the fundamental data that we shall have to consider in expressing the relation of consciousness to other mental processes, and demonstrating a physiological hypothesis for it.

Always Conscious of Something.—Another fact that must be considered is that we can never be merely conscious, we must be conscious of something. Consciousness can never exist alone. Consciousness is the accompaniment of an intellectual process, such as a perception, or the discovery of a relation or a feeling which it must accompany. The consciousness may be intense or feeble; it may vary in its intensity without any corresponding variation in the intensity of the process which it accom-

panies. We shall expect then, to find the physiological concomitant of consciousness in some element of the nervous current, or of the transmission of a nervous impulse through a nervous arc whose concomitant is an intellectual act.

Shadowy Background of Consciousness.—A third fact that must accord with any theory which we may present about consciousness is that in nearly every experience of which we are conscious, there is a shadowy background of other facts, events and processes, less vivid than the one that we may consider in the focus as representing the mental process for which consciousness is the accompaniment. This shadowy background is not necessarily present, and may be very much narrowed or altogether omitted; but its frequent presence materially assists us in suggesting a probable hypothesis for consciousness. These three facts will enable us to frame such an hypothesis when we consider them all together.

Origin of Expression.—We have described feeling as the concomitant of the resistance encountered by a nervous impulse in passing through a nervous arc. But we have recognized the fact that when a nervous impulse encounters resistance, it has a tendency to spread out into the surrounding cells. We have seen that this spreading out into the surrounding cells of the motor region and the glandular centers is the nervous correlate of the expression of feeling.

Radiation.—But not all of the impulse that radiates out of the brain center through which it is passing goes into the motor centers. Some of it passes into the fringing cells around the brain center and since these are not necessarily motor centers, no movement follows. If the radiating portion of the nervous impulse were to traverse these fringing cells as if they were other brain centers,

each brain center so traversed by the radiating impulse would accompany an intellectual process, fainter than the original, as the radiating impulse is weaker than the main impulse. It is in such a supposition as this that we can picture the dim, faint fringe of perceptions and other mental processes that accompany the conscious act. This would be the physiological explanation of the things that are in the fringe of consciousness.

The Fringing Cells.—But this background of faint perceptions and definite mental processes is not necessary to a conscious act. We may be conscious of the mental process in the focus without any of the fringing percepts. The nervous impulse may, and sometimes does radiate into the fringing cells without passing through them as a brain center and completing their circuit. We may say that it radiates into the fringing cells without running through them. This will stand to us for the concomitant of consciousness. The radiation of the nervous impulse out of the brain center into the fringing cells we may consider as the concomitant of consciousness. This will give us an interpretation of the process, enabling us easily to understand and to express the relation that it holds to other mental processes.

Radiation Depends Upon Resistance.—It is evident that the nervous impulse will not radiate out into the fringing cells unless some resistance is encountered in the brain center. The resistance itself is the concomitant of feeling, but the radiation which follows upon the resistance is the concomitant of consciousness.

Consciousness and Feeling.—It follows then, that if our interpretation of the physiological concomitant is correct, consciousness and feeling will vary together. Other things being the same, the greater the feeling the more intense will be the consciousness, and the less the

feeling the less intensity of consciousness. This result arises, not in consequence of any causal connection with each other, but because the two, consciousness and feeling, are both similarly related to the same circumstance, the amount of resistance encountered. Whatever increases the resistance, will at the same time increase both feeling and the intensity of consciousness. Whatever decreases the resistance will by that very fact decrease both feeling and the intensity of consciousness. Feeling is not the cause of the consciousness, nor is consciousness the cause of the feeling, but both of them are related in the same way to the antecedent condition, resistance.

Feeling and Consciousness Discriminated.—The above explanation will enable us to see the relation between feeling and consciousness, and will help us to understand that whenever we are experiencing any feeling we are conscious, and conscious of that feeling. It will show us why consciousness and feeling are not likely to be experienced separately from each other, but it will show us also how inaccurate is the expression that feeling is a state of consciousness, or that feeling and consciousness are identical.

Consciousness and Expression.—Similarly, our hypothesis will enable us to understand the relation between consciousness and expression. We might derive this relation indirectly by saying that since feeling and consciousness are directly related to each other, the laws that express the relation between feeling and its expression, would apply equally well to the relation between consciousness and expression.

Consciousness Homologous to Expression.—We have explained the expression of feeling as the radiation of the nervous impulse out of the primary brain center into the motor and glandular centers as a consequence of the re-

sistance encountered. In the radiation out into the fringing cells that are neither motor nor glandular centers we believe we have the concomitant of consciousness. It appears, then, that the expression of feeling and consciousness arise from the same circumstance and are consequences of the same condition. The difference between the two is merely the radiation of the nervous impulse into different kinds of cells and centers.

All Consciousness Motor.—Consciousness and the expression of feeling are, then, in a certain sense homologous to each other, and both of them may vary with each other and with feeling. If we choose to stretch a point, we may assert that consciousness is as truly an expression of feeling as is muscular movement itself. This is one way in which, if we choose, we may read a meaning into the phrase, a favorite with some authors, that all consciousness is motor.

Distribution of the Nervous Impulse.—We have now discovered that the nervous impulse that enters a brain center may be distributed into several portions, each the concomitant of a separate mental process. One portion passes through the brain center, and is the concomitant of the intellectual work done. Another portion is stopped out by the resistance it encounters, and is destroyed in overcoming it. This is the concomitant of feeling. Another portion escapes from the brain center, passes into the motor or glandular centers, and is the concomitant of expression. Still a fourth part escapes from the brain center, passes into the fringing cells that are a part of neither the motor nor glandular centers, and constitutes the concomitant of consciousness. A clear picture of these several parts into which the entire impulse is split up will help very much in the understanding of the relations existing among the different mental processes.

Consciousness and the Intellectual Process.—We have now discussed the relation between consciousness, feeling and expression. It remains to consider the relation of consciousness to the intellectual process. Since we have seen that consciousness and feeling are directly related to each other, we may expect to find that the laws of feeling will apply equally well to consciousness. That is, with a given amount of nervous energy, there is a reciprocal relation between consciousness and intellect.

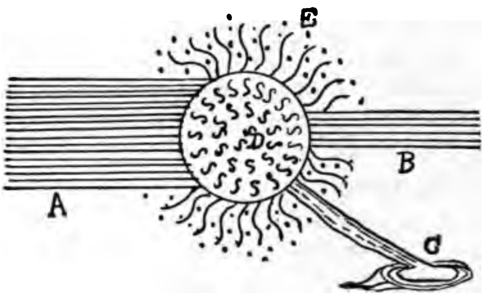

Fig. 36—A, the nervous impulse entering the brain center. B, the portion that runs through and is the concomitant of the intellectual process. C, the portion that escapes into the motor and glandular centers and is the concomitant of expression. D, the portion that is spent in overcoming resistance in the brain center and is the concomitant of feeling. E, the portion that radiates into the fringing cells that are neither motor nor glandular centers, and is the concomitant of consciousness.

Consciousness in Learning.—When we are learning to do a thing, we are intensely conscious of what we are doing. But as we become skillful in the act we can do it with less consciousness, and even perform it skillfully without thinking about it, or without being conscious of what we are doing. Consciousness tends to evaporate from an habitual act as truly as does feeling.

Consciousness and Skill Reciprocal.—Not only is consciousness not necessary to a psychic process, but it is

really detrimental to the action. The highest degree of skill has not been attained when we have to think how the action shall be performed. We are not conscious of the muscular innervations and contractions that are involved in the process of talking, and are unconscious of the movements that are made. But when we attend in such a way as to try to discover what the movements are, we speak very awkwardly, and our speech is not skillfully accomplished. The same thing is true of all our daily actions, and adjustments, both mental and physical. We know how to spell separate and many other words, if we do not stop to think, but if we stop to think, that is, to become conscious of our mental processes, we are as likely to spell the words wrong as right.

The Noise of a Wagon.—Consciousness bears about the same relation to the other mental processes that the noise which a wagon makes bears to the effective movement of the wagon. The old conundrum, "What is it that is no part of a wagon, but which the wagon cannot go without?" is directly illustrative of the point here. The wagon that makes the greatest noise is not the most effective tool for the purpose for which a wagon is employed, nor is it in the most satisfactory condition to use. The wagon that moves with the least noise, other things being the same, is in better condition for work. There is less energy lost in overcoming the friction.

Consciousness and Feeling Both Reciprocal to Intellect.—Our actions, mental and muscular, accomplished without consciousness and without feeling, are better done and more accurately performed with the same amount of nervous energy than if feeling and consciousness accompanied them. Less resistance is to be overcome, and more energy is available for doing the work.

Utility of Consciousness.—Consciousness implies hesitation and delay, and consequently, an opportunity to select and make choice between alternative possible actions. It is then a condition incident to deciding or choosing, or adjusting oneself to new and non-habitual situations. This seems to be its advantage in the development of the race. It is a condition that permits of deliberate adjustment, and assists in the learning of a new process.

Variation in Consciousness.—Consciousness varies in intensity as truly as does feeling. Sometimes we are intensely conscious, and again we are relatively unconscious. Consciousness and unconsciousness are relative terms; it is impossible to draw an exact line between them. Try to decide upon the instant at which you have ceased to be awake and have fallen asleep, and the difficulty of discriminating between absolute consciousness and a state of absolute unconsciousness will be understood.

Effect of Habit on Consciousness.—There are at least four ways in which the intensity of consciousness may be increased or decreased. First, the effect of habit is to decrease the intensity of consciousness, as has already been described. The only way to conceive of the effect of habit upon consciousness is by recognizing that the resistance in the brain center is decreased, and the relation that resistance holds to consciousness.

Effect of Attention.—Second, consciousness may be increased or decreased by a process of attention, whose mechanism we are not yet ready to discuss. We may study our lesson with such intensity of attention, or be so completely absorbed in some other object of contemplation that we are not aware of the passage of time, or events that occur in the room in which we are studying.

This is the condition in which we may escape from a great danger, without being aware of how we escaped, or the dangers that we passed through. The unconsciousness of the hypnotic state will serve as an example of this condition of unconsciousness.

Effect of Decrease of Nervous Energy.—Third, resistance may be diminished and consciousness consequently decreased by the decrease in the amount of nervous energy generated. This process is manifested as the primary condition of sleep, which constitutes the subject of the next chapter.

Effect of Excessive Resistance: Chloroform.—Fourth, consciousness may be decreased, or completely obliterated by an increase in the amount of resistance to such an extent that the circuit is broken, and no nervous current flows through any brain center. This condition of unconsciousness is found in cases in which a person faints from excess of emotion. It is also the condition resulting from the administration of chloroform, not from that of morphine. The probability is that chloroform causes a shrinking and retraction of the dendrites and so increases the resistance between the neurons in a brain center to such an extent that a nervous impulse will not pass, and unconsciousness ensues.

SIDELIGHTS

By consciousness we mean a man's awareness of his own acts and their antecedents.—*Pillsbury, Essentials of Psychology, p. 4.*

Consciousness is a cognitive, an intellectual state. It means an awareness of one's own mental processes.—*Bolton, Principles of Education, p. 328.*

Nerve processes are not all of the kind which we have reason to think accompanied by consciousness, and even those with which this is the case may be carried on without consciousness if their intensity is not sufficiently great.—*Höffding, Psychology, p. 71.*

The term consciousness is equally ambiguous; it may mean simply what is experienced; it may mean our knowledge of that experience; or it may mean a state to which our mental realities, otherwise unconscious, may somehow attain.—*Külpe, Psychology, p. 2.*

Many distinguished thinkers, especially on the physiological side (Wundt, Ziehen, etc.), take the ideas of consciousness and psychic function to be identical: "All psychic action is conscious." "The province of psychic life is coextensive with that of consciousness." In our opinion, such a definition gives undue extension to the meaning of consciousness, and occasions many errors and misunderstandings. We share rather the views of other philosophers (Romanes, Fritz Müller, Schultze, and Paulsen) that our unconscious presentations, sensations, volitions, pertain to our psychic life. Indeed, the province of these unconscious psychic actions is far more extensive than that of consciousness.—*Haeckel, Riddle of the Universe, p. 172.*

Let us repeat it, psychical and conscious are for us, at least at the beginning of our investigations, identical.—*Ziehen, Physiological Psychology, p. 5.*

From the outstart, the conception unconscious psychical process is for us an empty conception.—*Ziehen, Physiological Psychology, p. 5.*

The error has been in confounding two quite distinct things: having a sensation, and being conscious of having a sensation.—*Spencer, Psychology, Volume II, p. 372.*

Consciousness accompanies the psychological processes of reasoning, sensation, recollection, etc. It does not constitute them. It is an epiphenomenon and nothing more.—*Binet, Psychology of Reasoning, p. 91.*

Ultimate analysis of psychical processes shows that the unconscious is the theater of the most important mental phenomena. The conscious is always conditioned upon the unconscious.—*Ribot, German Psychology, p. 191.*

I can receive a sense impression without recognizing it, for a sense impression does not involve consciousness.—*Karl Pearson, Grammar of Science, p. 43.*

Consciousness may be compared to an internal light by means of which, and which alone, what passes in my mind is rendered visible.—*Hamilton, Metaphysics (Bowen), p. 120.*

Consciousness is the recognition by the thinking subject of his own acts and affections.—*Hamilton, Metaphysics, p. 131.*

We can be conscious only as we are conscious of something.—*Hamilton, Metaphysics (Bowen), p. 132.*

Consciousness is the perception of what passes in one's own mind.—*Locke, Human Understanding, Book II, Chapter 1, Section 19.*

The radiation of nerve force from strongly excited nerve cells to other connected nerve cells may help us to understand how reflex actions originated.—*Darwin, Expression of the Emotions, p. 41.*

It is true and universal that consciousness tends to disappear from reactions as they are oftener repeated.—*Baldwin, Methods and Processes, p. 168.*

DEFINITIONS

Consciousness.—The knowledge of our own mental states and processes; or, the process by which our own mental states and processes become known; or, the property of a mental state or process by which we know it.

Radiation.—The running out of a nervous impulse into the fringing cells.

Fringing Cells.—Those brain cells which do not constitute a part of a brain center, but which are closely connected with it.

CHAPTER XX

Sleep and Dreams

Sleep.—The phenomena of sleep are universal in the human race. It is a state of unconsciousness, and dreams are unconscious mental processes manifesting varying degrees of intensity in their unconsciousness. Many psychologists place the phenomena of sleep and dreams in their chapter on Abnormal Psychology, but sleep and dreams are not abnormal, nor are they non-psychical. Those who define psychology as the science of consciousness, and assume that no unconscious process can be mental, have no place for the discussion of sleep and dreams.

Why Study.—It is quite necessary for us to study sleep and dreams. The universality of the phenomena, together with the amount of time that we spend in sleep, would seem to justify a great deal of attention to its accompanying mental states. One-third of our lives is spent in sleep. It is not unusual to find persons who have spent twenty years in bed, without being serious invalids. The twenty years are distributed over a lifetime of sixty.

Influence of Dreams.—In the experience of dreams, we have a series of phenomena which have largely influenced our philosophical and religious beliefs, and shaped our decisions upon many questions. Perhaps the dualistic philosophy finds its strongest support, and belief in it has become so general, in consequence of the experience that every one has had with dreams. The person who goes to sleep and in his dream finds himself in places far distant from that in which he went to sleep, and who

talks with and sees other persons, some of whom he knows and some of whom are strangers; some of whom are living in the same places in which he himself lives, and others that he knows to be living in distant lands; some of whom are living and some of whom are dead; when a person after having such experiences awakens and finds that his body is in the same place in which he went to sleep a few hours or minutes before, it is the apparent, easy and inevitable explanation that in some way he has been able to know the things of his dream as he would know them if he were freed from the limitations his body imposes. Hence it is inevitable that he should adopt the suggestion, even if he would never originate it himself, that his body is distinctly separate from an immaterial thing known as his soul, spirit, or mind, which has traveled in the places of his dreams.

Belief in Immortality.—Out of this easily grows the belief in immortality of the soul and freedom from the limitations imposed, not merely by space and time, but by disease and death. If it were not for the phenomena of dreams, belief in immortality would be far more difficult to inculcate.

Dream Books.—Dream books are printed and sold in large quantities. Many persons have a more or less profound faith in the prophetic character of some dreams. The phenomena of dreams, then, influence the lives and daily actions of many persons. On this account, no study of psychology can afford to overlook the phenomena.

Sleep Universal.—Sleep is universal in the human race, and is of so much importance that a person will die sooner from loss of sleep than he will from lack of food. We may readily conceive that this character of sleep has become fixed in the human race by the processes of natural selection.

Established by Natural Selection.—Let us suppose that in the early stages of the human race, or of its prehuman ancestors, there existed a condition in which some did not sleep while others did. Our principal means of escaping from danger depends upon our being able to see. At night this means of escape is greatly lessened. Those who wandered widely at night would meet dangers from wild animals, dangerous rivers, swamps, from rock precipices and from many other things which those who did not wander at night would avoid. Those who possessed the habit of sleeping at night would avoid these dangers. Hence it would inevitably happen that those without the characteristic of sleeping at night would encounter more dangers, more of them would be killed, fewer descendants would be left, and a smaller number of them would survive, than of that group who, in consequence of the characteristic of sleep, remained at home at night in their sheltered places. Ultimately, only those in whom the character of sleep manifested itself would survive and leave descendants.

Nocturnal Sleep.—Our sleep is a nocturnal sleep, and recurs at intervals of twenty-four hours. It has its advantage in the fact that the earth rotates on its axis in that length of time and produces the succession of day and night. Had the length of the day been different, it is probable that our interval for sleep would have been otherwise than it is now.

Hibernation.—We shall be able to appreciate this only by comparing our nocturnal sleep with the winter sleep, or hibernation, of other animals. The black bear once ranged over North America. It lives mainly on vegetable food. It can eat animal food, but is not well adapted for catching prey. In winter, its principal source of food disappears, and it must accommodate itself to the changed

condition. The same conditions prevail in the case of hedgehogs, bats and birds. They may overcome the difficulty in three or four ways. They may store up food for winter, as man does, and as some squirrels do. They might ship in food, as man does. They might migrate, and travel from the place where food is not to where it is, as birds do. But bears are not well adapted for flying through the air, and they have adopted a fourth method. They go to sleep when food becomes scarce and sleep all winter. Sleep is a condition in which little nervous energy is generated, and there is very little oxidation of tissue; consequently little food is needed. A bear sleeps about three months, using up the food that has been stored in his body as fat.

Estivation.—Estivation, or summer sleep, is a manifestation of the same principle. In countries where the seasons are only two—wet and dry—animals and plants would perish in the dry season if they maintained their usual amount of activity. This condition is avoided by the animals burying themselves in the mud before the water entirely dries up, and there they remain in sleep until the rains come again. Nocturnal sleep, hibernation, estivation are manifestations of the same principle, differing only in the conditions to which by their means the different animals are adjusted. From this also we might infer something of the nature of the climate in which the human race originated. It was evidently not one in which the wet and dry seasons prevailed, nor one in which the winters were long and severe.

Sleep and the Nervous System.—Sleep is a characteristic of mammals, birds, reptiles, batrachians and insects. When we arrive at a place in the animal scale in which the nervous system is less complicated than it is in insects, it is doubtful if the phenomena of sleep are mani-

fested. We discover no indication of sleep in those animals that have no nervous system, and even in the animals that possess a nervous system we fail to discover that it is universal. It is doubtful if fishes ever sleep. It seems as if the animal must have a nervous system of a considerable degree of complexity before the phenomena of sleep manifest themselves.

Sleep Correlative to Consciousness.—We have associated sleep with consciousness, and we might infer that where consciousness does not manifest itself, there is no occasion for the phenomena of sleep. Conversely, if we can discover an indication of sleep, we have a fairly satisfactory evidence of the existence of consciousness, and consequently by inference, of intelligence in a general sense of the term.

Advantage of Sleep.—There is a distinct advantage in sleep other than escape from nocturnal dangers. The essential condition of sleep is lessened brain activity, less oxidation of tissue, and consequently a lessened amount of nervous energy generated. No matter what conditions bring this result about, sleep follows. When there is this lessened amount of oxidation of tissue, there is a better opportunity for the elimination of waste products that have accumulated in the system, and for the restoration of the tissues that the larger activity of the waking hours has depleted.

How Sleep Restores Tissue.—If it were not for this diminished amount of oxidation of tissue and consequent decrease in nervous energy, there would be no advantage in sleep as a restorative. Sleep is not any mysterious process, imposed from the outside, nor is it in itself a restorative at all. Its efficiency results from the fact that less nervous energy is liberated.

The Primary Condition.—As we have already stated,

the primary condition of sleep is a diminished amount of nervous energy. When a smaller amount of nervous energy is passing through any brain center, there is less resistance, and less feeling, less radiation and less consciousness. The intensity of consciousness is so slight that we properly designate it as unconsciousness.

How Established.—This primary condition may be brought about in several ways, or there are many conditions that contribute to the reduction of the amount of nervous energy. In the first place, the brain is always, or nearly always, anaemic in sleep. That is, it is supplied with a smaller amount of blood than in the usual waking state. Any process that tends to diminish the supply of blood to the brain is favorable to sleep. Under the ordinary waking conditions, from one-twelfth to one-eighth of the blood that leaves the heart is sent to the brain. In sleep, usually, perhaps not always, a much smaller proportion is carried.

Blood Supply in Sleep.—To bring about this lessened blood supply to the brain, the heart beats more slowly, and a smaller quantity of blood is sent out from the heart at each pulsation. A larger proportion goes to the skin, and consequently in sleep the skin is warmer than in the corresponding waking condition, and there is a greater amount of secretion by the glands of the skin.

Effect of Food.—Food taken into the stomach tends to induce sleep. The blood is determined to the stomach in digesting the food, and a smaller quantity goes to the brain. In the same way, hot baths induce sleep, determining the blood to the skin, and thereby diminishing the quantity that goes to the brain. Exercise, in just sufficient amount to determine the blood to the muscles is also favorable to sleep, but the effect is counteracted in a large measure by the quickened circulation, and the

greater amount of oxygen taken into the lungs. Loss of blood induces unconsciousness for the same reason, and pressure on the carotid arteries will bring on unconsciousness in thirty seconds.

Effect of Diminished Oxygen.—So far, we have been considering only one factor, that of blood supply to the brain. But the diminished blood supply is favorable to sleep only because it results in a smaller supply of oxygen to the brain. If the supply of oxygen is diminished the same result follows as if the blood supply is diminished. Consequently we find in sleep that the rate of breathing is slower, and that a smaller amount of air is taken into the lungs at one inspiration. If the air that we breathe is impure, and not well supplied with oxygen, we become sleepy. Even if there is nothing deleterious in the air itself, but an unusually large proportion of an inert gas like nitrogen, sleep will follow.

Diminished Peripheral Impulses.—There is still another condition of sleep. When we wish to go to sleep, we close our eyes and shut out the light. We get away from noises; we wish to be neither too hot nor too cold; we desire a reasonably soft mattress, and we wish to avoid experiencing the sensation of hunger. In fact, so far as possible, we avoid all peripherally initiated impulses. These are always stronger than centrally initiated, and therefore have a greater tendency to radiate and to accompany the phenomenon of consciousness, which is the contradictory condition of sleep.

Effect of Starvation.—While hunger is not conducive to sleep, excessive hunger, designated as starvation, is. A person who is fasting for long periods finds that he sleeps a great deal of the time. In this condition, it is not lack of blood supply, nor of oxygen to the brain that prevents oxidation of tissue, but it is lack of tissue to be

oxidized. The effect is the same, and our explanation of sleep seems to cover all possible conditions.

Variation in Depth of Sleep.—Consciousness varies in intensity from the most complete consciousness to the lowest degree of unconsciousness. Consciousness and unconsciousness are relative terms. So sleep may be intense or feeble, deep or shallow. We may be half asleep or half awake, and the difference in the two condi-

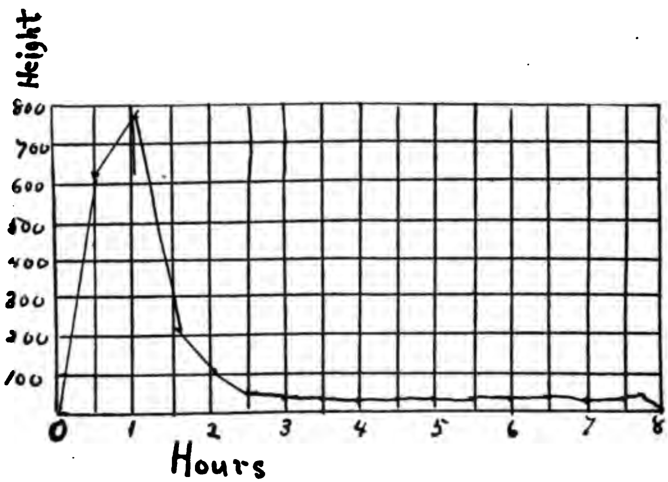

Fig. 37—Curve showing the depth of sleep at each hour in the night. The height is that from which a ball was dropped to awaken a sleeper.

tions is not very great. Experiments have been made to measure the intensity, and in one of the most successful of such experiments, the sleeper was awakened by the noise produced by dropping a metal ball upon a brass plate outside of the room door. The height from which the ball must be dropped in order to awaken the sleeper was taken as the measure of the intensity of sleep.

The Sleep Curve.—By this method it was found that in the ordinary night's sleep, the deepest intensity was

reached about the beginning of the second hour. From this point is gradually decreased in depth until about the end of the fourth hour, when its intensity was not very great. There was a fairly uniform intensity not much below the line of consciousness until the end of the eighth hour, or the time of natural awakening, with a tendency to a slight second maximum, or deepening of sleep in the last hour, just before awakening.

Dreams.—In sleep there is mental action going on, which we call dreaming. The older psychologists could not account for this action of dreaming and refused to call it mental. They spoke of unconscious cerebration, or brain action, as distinguished from mental action. But we have reason to believe that much of our most important mental action is unconscious, and we have no reason for refusing that designation to dreams.

Continuity of Dreaming.—Nearly everybody dreams. The deeper the sleep the less mental action and the less dreaming, while there may be occasions in which all mental action ceases. It is the usual thing, however, for mental action to continue throughout all the hours of sleep. We do not remember all the dreams we have, and those dreams that we experience just before waking up are the only ones that we are usually able to reproduce. Sometimes we are suddenly awakened just as we are going to sleep, and then we discover that we were dreaming at that time. In this way we know that we dream as we go to sleep, and as we awake, and whenever we are awakened we find that we are dreaming, hence we are inclined to believe that we dream nearly all the time that we are asleep.

Best Remembered Dreams.—We remember best only those dreams that we experience as we awake. There are two reasons for this: one is that these dreams have oc-

curred most recently, and there is less chance to forget them. The second is that they occur just as the person is approaching the conscious state and consequently the amount of nervous energy is great enough to accompany an experience sufficiently vivid to be remembered.

Vividness of Dreams.—Sometimes we experience what we describe as a vivid dream. On examination we shall find that the vividness is mostly an illusion. Compared with other dreams it may be vivid, but compared with a waking experience it is never vivid.

Less Vivid Than Waking Experience.—If a dream were as vivid as a waking experience, it would be as easily remembered. But if a dream is not reinstated, reproduced, recalled, talked about or thought of for six hours after waking up, it will be found impossible to reproduce it. Such a test applied to a waking experience will show that it is different in this respect. Another test is that of comparing the intensity of the experience as soon as awakened, with corresponding experiences when awake. For example, a sun illuminated snow covered landscape seen in a dream was judged to appear about as bright as the same landscape would have appeared if it had been illuminated by the full moon. The probability is that the vividness of the dream corresponded to the vividness of a waking experience of the same kind as full moonlight would compare with sunlight.

Lack of Vividness Explained.—This demonstration of the small amount of vividness in dreams is explained by the fact that there is but little nervous energy generated in sleep, and only weak nervous impulses traverse the brain centers in dreaming. It is not only explained by that supposition, but it directly corroborates our interpretation of the nature of sleep.

Elements of a Dream.—When we dream, a nervous impulse passes through some brain center. If it passes through some combination of cells in the occipital lobe, we experience a visual dream. If it passes through some combination of cells in the temporal lobe, we have an auditory dream. Most of our dreams are auditory or visual, and frequently both. If a person has become blind before the age of five years, his dreams are never visual nor will they contain visual elements. Tactual elements may enter into a dream, and so may images of taste and smell, but these latter are rare.

Peripheral Direction of Dreams.—All of our dreams are faint, accompanied by nervous impulses of little intensity, and nearly all of them are centrally initiated. Sometimes, though not always, a peripherally initiated impulse, started in some sense organ, gives direction to a dream. Many persons have supposed that every dream was thus originated and directed, but such a supposition cannot be maintained without giving undue extension to the meaning attached to peripherally initiated impulses.

Fantastic Character.—One of the most characteristic features of dreams is their fantastic nature. Many times they appear to be wholly unreasonable, but their unreasonableness does not appear to the dreamer. This may be accounted for by the fact that attention is completely inactive in sleep. The nervous impulse is not directed, but follows the path of least resistance at the moment. It encounters little resistance, engenders little feeling, and this in itself is a condition when any unreasonableness would not be recognized, since no feeling, even of surprise, is likely to be experienced. When the impulses become strong enough to engender feeling, we awaken.

Not Prophetic.—Notwithstanding the very general belief to the contrary, dreams are not prophetic. It may

be that in some cases, an event that has constituted the subject matter of a dream, has afterward occurred, but many more events dreamed about have not occurred. In the millions of dreams every night, and the millions of events every day, it would be very strange if there should not be some coincidences; but for most of the coincidences very good reasons can be alleged. If an event is expected to happen, or not to happen, it must do one or the other; and a person who dreams of the event has one chance in two of his dream being fulfilled. In a few cases, the oncoming of disease has been recognized in sleep, but this may be accounted for by the fact that in sleep the impulse is not directed by the attention, but follows the path indicated by the actual condition of the brain. In this way it may give an indication of a diseased condition that has not been previously observed. This is the only kind of prophetic dream that has ever been supported by satisfactory evidence.

Mental Work in Sleep.—There are many instances of mental work of value having been done in dreams. In fact, any person who has a difficult lesson to learn, may practically learn it in sleep if he reads it over carefully just before going to sleep and thinks of it until sleep ensues. It seems that the mental activity in sleep has avoided the difficulties imposed by the processes wrongly directed by attention. A smaller amount of nervous energy relieved from the usual amount of resistance, accomplishes much work.

Kubla Khan.—Coleridge is said to have dreamed the whole poem of Kubla Khan, and upon awaking wrote it out just as he dreamed it. He said that there were twenty or thirty lines more of the poem that he could not remember, and was ever afterward unable to reproduce. Also the story is an old one of one of the great

mathematicians who, upon going to bed, after having tried vainly to solve a problem, was astonished in the morning to find the solution carefully written out on his table, in his own handwriting.

Awake at a Previously Determined Time.—One other phenomenon of sleep deserves notice. Many persons are able to awaken at any time that they have previously decided to wake up. The experience is the same thing as the ability to think of anything that we have decided in our waking hours to do at any particular time. When that time comes we think of the thing we have decided to do, or we are very much disposed to censure ourselves for failing to think of it. We do not know the mechanism of the process by which the result is brought about. But the occurrence of the same phenomenon in sleep is merely another evidence that the sleeping state differs only in one essential respect from the waking state, and that we have called the diminished amount of nervous energy manifested.

Somnambulism.—Sleep walking and sleep talking are motor phenomena, and are explained by the fact that the nervous impulse is strong enough and encounters resistance enough to flow out into the motor, or expression, centers. Both of them are likely to be associated with more or less abnormal conditions, giving rise to peripherally initiated impulses, such as accompany the distressed feeling from an overloaded stomach, or a condition of brain tissue that more or less closely approximates inflammation. Nervous impulses of an unusual degree of intensity for sleep readily explain the existence of the phenomena, although if the impulses become strong enough, the person awakes, the impulse radiates out into the fringing cells, and consciousness follows.

SIDELIGHTS

In sleep there is a diminution of arterial blood to the brain.—*Bain, Mind and Body, p. 15.*

The condition of anaemia in connection with the withdrawal of external stimuli causes a depression of the psychical processes below the threshold of consciousness.—*Manaceine, Sleep, p. 54.*

The psychical phenomena of dreams and the conscious life of waking hours are different, but they do not have a different psychical value.—*Ziehen, Physiological Psychology, p. 267.*

It is only in the most vivid dreams that either men or animals (especially hunting dogs) give a weak expression to the somnial ideas of motion by a few slight movements of the trunk and extremities. In sleep, therefore, the initial element of the psychical process, the sensation, is produced by ideational stimulation, and the final element is almost omitted.—*Ziehen, Physiological Psychology, p. 265.*

DEFINITIONS

Sleep.—A condition of unconsciousness arising from a diminished amount of nervous energy liberated.

Dream.—Any kind of mental action in sleep.

Hibernation.—The winter sleep of such animals as bears and hedgehogs.

Estivation.—The summer sleep of animals in countries that have the wet and dry seasons.

Anaemia.—A condition of diminished blood supply.

Somnambulism.—Sleep walking, or motor phenomena in sleep.

CHAPTER XXI

Memory

Memory Defined.—Memory is the reinstatement of a previous mental experience with the same conscious elements. It is the concomitant of the transmission of a nervous impulse through the same cells and centers that it passed through before, and the radiating out into the same fringing cells. The mental experience is reinstated and recognized. In this, as in all other definitions of memory, two different elements are introduced. One is the element of mental reproduction, and the other is the element of mental recognition. Neither, without the other, can be called memory.

Mental Reproduction.—Mental reproduction is the concomitant of the transmission of the nervous impulse through the same cells and centers that it passed through before. Some psychologists appear to believe that in mental reproduction the nervous impulse traverses a different combination of cells from those that were traversed in the original experience. That is, in an original experience, such as perceiving a landscape, the nervous impulse traverses combinations of cells in the sight center in the occipital lobe, while in remembering the landscape, the impulse traverses only combinations of cells in the association centers, and passes through none of the cells in the sight centers.

An Idea.—However, this interpretation has very little to commend it, and may safely be rejected. The remem-

bered process is very properly designated as an idea, and differs from the original experience principally in vividness, although as a consequence of the difference in vividness, it is not so accurate as the original and is accompanied by less feeling. As a corollary of this interpretation of memory, it will be seen that there can be no memory center in the brain.

Mental Recognition.—But mental reproduction is not memory. If the idea is reproduced without being recognized as having been experienced before, it is not memory. When the original experience occurred, we were conscious of it, or it would not have been remembered. That is, the nervous impulse which accompanied it, encountered resistance and radiated out into the fringing cells. When the impulse is reinstated, it must radiate out into the same fringing cells, thus accompanying the element of consciousness, and since the fringing cells are the same as in the original experience, we recognize the idea as one that has been experienced before. The radiation out into the same fringing cells is the concomitant of the element of mental recognition.

Reproduction Without Recognition.—This hypothesis of memory seems to satisfy every condition and will assist us very much in understanding our experiences with it. If our interpretation is correct, we shall see that it is possible to experience the element of mental reproduction without the element of mental recognition. The writer one time deliberately coined a word, to express an idea he wished to use in a paper, and then within a month read that same word in a book in his library. When coining the word, he was unconscious of ever having seen it before. But after having read it many times in books published before the word was used in his paper, he became convinced that he had read the word many times,

and when it appeared as the expression for the idea, it was reproduced without being recognized.

A Common Occurrence.—Probably nearly all of our brilliant ideas are unrecognized reproductions. We fail to recognize them when they appear, and we believe that we have originated them. Seldom is it possible to detect ourselves in reproducing an idea without recognizing it, but the difficulty lies in the failure to detect it, not in the fact itself.

A Necessary Condition.—More than this. It seems to be necessary that the element of mental recognition shall disappear from the reproduced experience before it can be thoroughly organized into our system of knowledge and be completely known by us. It has not become a usable piece of our mental furnishings until such organization has taken place. It is generally better for us to study one lesson from several books than it is to study the same lesson several times from the same book. The essential elements of the lesson are likely to be found in each of the several books and be reproduced, but the non-essential elements will not appear in all the books, and will therefore not obscure the more important. Recognition interferes with organization of mental content.

Recognition Without Reproduction.—But can the element of mental recognition exist without the element of mental reproduction? How do we know that we are trying to remember anything unless we know what it is that we are trying to remember? The question seems absurd on the face of it, but it may not be so absurd as it looks. We have seen that the element of mental recognition has for its concomitant the radiation of the impulse into the fringing cells, or neighboring brain centers. Suppose that the nervous impulse gets into the fringing cells without having reached them from the original center.

Then we may experience the element of mental recognition, or have the feeling of familiarity, without the mental reproduction.

Process of Remembering a Name.—Let us suppose that we are trying to remember a man's name. I know that there is a man and that he has a name. He is a school teacher, and principal of a school at Rosedale. The nervous impulse is traversing the combinations of cells that correspond to the ideas Principal, and Rosedale. I am trying to direct it from that center over into the name center. It will not go. I think of another circumstance. He is a man of about forty years of age, wears sandy whiskers. The nervous impulse is now passing through a brain center corresponding to that idea. I try to make it go into the name center and it will not go. Then I think of another circumstance. He has a wife and two children. I saw them on the street car last Sunday. Now the nervous impulse is passing through a combination of cells that corresponds to this experience, and I try to make it pass from this combination into the name center and it will not go. Then I think of another circumstance. He wished me to write him a letter of recommendation to the Board at Springfield. His name is Hollister.

The nervous impulse has, after repeated trials, found a center from which the resistance into the name center is smaller and finally passes into it. While it is traversing the centers corresponding to the related circumstances, we may say that we are experiencing with greater or less degrees of adequacy, the element of mental recognition, and we should immediately recognize the name as being the one that we are trying to remember if we should hear it. Something like this will enable us to understand the feeling that we experience in the very common situations

when we are trying to reproduce an experience and fail to do so.

Advantage of Many Related Circumstances.—The illustration above will also enable us to see the advantage in having many related circumstances if we wish to remember anything. If the nervous impulse can make a choice of a route from any one of four combinations of cells into the primary center, it is more likely to pass into that center than if it is limited to one. The chances are about four to one that it will find a passable route into the primary center if there are four alternatives instead of only one.

Attention Detrimental.—The illustration will also furnish us another corollary which will explain experiences that have occurred to every person. We have often tried to recall some circumstance when we needed to use it, and we have been distressed at our inability to do so. We have been compelled to lower our estimate of ourselves by our failure to recall it, and when we have given up in despair, and all opportunity to use the circumstance advantageously has passed by, and we have ceased to think of it, the circumstance placidly appears, and innocently inquires if we called it. We are unable to give it the proper reception, but if it were a person we should know exactly what to do and how to express our opinion of it.

Remember Best Without Attention.—When we are trying to recall the circumstance, we are trying to direct the impulse into the primary center by a process of attention. We are in effect forcing the impulse over a path of our own choosing, and in all probability we have not selected the path most easy of access, and so the impulse fails to reach the appropriate center. When we cease thinking about it, and trying to direct it by atten-

tion, the impulse seems to wander freely and finds the easy road into the primary center. This figure will help us much in understanding the process that we have all experienced.

Memory Essential to Mental Life.—It is not too much to say that without this ability to reproduce a past experience there would be no mental life. Our mental life is absolutely dependent upon the memory. If it were not for memory, our conscious life would be limited to the specious present which is the interval of one pulsation of consciousness. In the larger number of cases, this interval is about three-fifths of a second. If we should learn to take a step, and could not then remember in the next three-fifths of a second what we have learned, we should be under the necessity of learning anew how to take the second step. All mental life would be impossible, and everything would have to be learned anew on every occasion.

Basis of Education.—So important is memory that it has been assumed to be the chief educative process, and teachers have acted upon that assumption. Training the memory has in times past been regarded as the principal function of the school. Generally, the people regard the one who knows the most and has remembered the greatest number of facts as the most learned and the best educated man. It can easily be shown that this involves a fallacious assumption. In fact, memory is sometimes a positive detriment to education. Suppose that every one in the class could remember without effort every word in this chapter, and when called upon to recite would state the words of the book. Neither the learning nor the recitation would be an educative process, and a phonograph would do as well. In reciting, the teacher would be unable to judge of the amount of thought that the words

really expressed, what ideas had been obtained from the words, and whether or not the words really represented to the individual any ideas at all. In order to be educated, we must think, perceive relations, organize the subject in our own mind. Memory does not do that, but only furnishes us the material for thought which we are to organize, and among which we are to perceive the relations.

Importance of Forgetting.—It is just as necessary that we shall forget as it is that we shall remember. The little boy who defined memory as the thing we forget with, was not very far wrong. If we could not forget, it would take us as long to reproduce an event that occurred in the past as it did to experience it in the first place, and the result would be as disastrous as if we could not remember anything. In the process of thinking, it is necessary that we should hold up in mind two ideas at the same time, and bring them into juxtaposition. If the two ideas or events were originally separated by an interval of time, such as that one occurred yesterday and another today, without the ability to forget, we should be unable to bring the two ideas together, and thinking would be impossible.

First Rule of Remembering.—Most of us are sufficiently skillful in forgetting, and we feel that it would be much better for us if we could remember more readily. There are three rules for remembering that contain everything that is of value in any system of memory instruction. One of these is that we must give the greatest possible attention to anything when we are learning it. This means that we must drive the greatest possible amount of nervous energy through the new combination of cells the first time. The greater the amount of nervous energy driven through the ner-

vous arc, the more the arc will be modified and the easier it will be for the next impulse to pass through. Also, this will nearly inevitably be accompanied by considerable feeling, for the large amount of nervous energy will necessarily encounter considerable resistance in passing through the brain center that has not been traversed before.

Memory and Feeling.—This fact will afford an explanation of the belief that we remember only what we learn with feeling. It shows us the relation between feeling and memory. If the feeling arises as the result of the resistance accompanying the transmission of a greater amount of nervous energy, the more feeling, the better we shall remember. But if the feeling occurs as the concomitant of the resistance arising from the poor quality of the nervous arc, then we shall not remember in consequence of the feeling. Most of the persons with prodigious memories do not experience much feeling in the process of learning. Those with ordinary memories who experience feeling in learning do not remember so well as do those of extraordinary memory who learn without feeling. It is not the feeling, but the condition that accompanies the feeling, that is the occasion for remembering well.

Difficult to Apply.—The large amount of nervous energy driven through the brain center is the concomitant of a good deal of intellectual work. We may express it by saying that we should see a thing that we are trying to learn very clearly, we should get just the thing before the mind, not merely something like it. This is the necessary result of a large amount of nervous energy and careful attention. But attention is a difficult process, it is hard work, and most of us are lazy, and will not likely employ this process of remembering.

Second Rule.—A second rule for remembering is to associate the thing we are learning with as many related circumstances as possible. The explanation of this rule has been already discussed in the example of the process of remembering a name. The nervous impulse is more likely to find some pathway of easy access into a particular brain center if it has many avenues of approach than if it is limited to a single avenue. It is true that the one avenue may be just the one that would be most easy of access, even if there were a dozen others, but the possibility is strong that some one will be more open than a particular one. This rule is little recognized and little heeded when we wish to remember. It is, however, a most effective process for remembering.

Third Rule.—The third rule is repetition, and is the one that we all know and the only one that we consistently employ. The more frequently a nervous impulse traverses a brain center, the more it modifies the arc and the less resistance is encountered. It is another illustration of the law of neural habit. But repetition without attention has little value, while repetition with attention has much. Repetition will have value in remembering in just about the proportion that it is accompanied by attention.

Experimental Investigations.—Some very important investigations in remembering have been carried out experimentally within a few years. The method of making these experiments is to construct a large number of nonsense syllables by inserting a vowel between two consonants. Then by trial discover how many of these nonsense syllables can be learned by one reading, or how many repetitions are necessary to learn a given number of syllables. Instead of nonsense syllables, series of figures have been employed, or stanzas of poetry. From

such investigations, valuable conclusions have been reached.

Rate of Forgetting.—By methods of this nature we know how rapidly we forget. The rate of forgetting is determined by discovering how many repetitions of a series of syllables are necessary to relearn it after a certain time has elapsed. If it required 24 repetitions to learn a series originally, and after a number of hours, the series must be repeated 12 times before it can be reproduced, it is assumed that one-half has been forgotten in the interval. In this way it is known that we forget about half of what we have learned in the first six hours after learning it. In 24 hours we forget about two-thirds, and in six days about three-fourths, while in one month we forget four-fifths. The precise amounts make little difference, but the general law is unquestionable that forgetting is most rapid in the first periods after the learning has occurred.

Retroactive Inhibition.—Especially is this true if after having learned anything we turn immediately to learning something else, or to engage in some other activity. If after having learned a series of syllables we turn immediately to the study of another lesson, or engage in some other activity, we forget fully one-half of what we have learned in the first five minutes. The practical application of this is that if we wish to remember what we have learned, we shall refrain from doing any kind of work, and shall let our mind be as nearly blank as possible for five minutes after the learning has been completed. This fact is called the law of Retroactive Inhibition.

Divided Repetition.—Another fact, or law of remembering that has been discovered by experiment is called the law of Divided Repetition. This means that if we

wish to learn the largest possible amount in a given time, we shall not employ the entire time at once, but will divide it up into about four intervals. That is, if we wish to learn the greatest amount possible in two hours, we shall divide the study into four periods of half an hour each, separated by an interval of an hour or more. The advantage seems to arise from what has been called the perseverance tendency. This is the same tendency that we have described in our lesson on sleep and dreams in which the learning seems to go on in sleep while we are unconscious.

Third Law.—A third law of learning is that it is economical of effort to learn anything as a whole instead of learning part of it thoroughly before beginning to learn the next part. If we wish to commit to memory a poem of ten stanzas, it is unwise to memorize the first one before beginning to memorize the second. We should learn the whole ten together instead of each one singly. This law applies to tasks up to the length of those that require forty-five minutes to learn them, at least.

Number of Repetitions.—The number of repetitions required to learn a series of syllables rapidly increases with the number of syllables. In an experiment of Ebbinghaus, it required only one repetition to learn seven syllables, while to learn 12 required 17, and to learn 16 required 30.

Memory and Consciousness.—We have already described the relation between feeling and memory, and have seen the explanation of the fact that the things we learn with feeling are best remembered. In the same way, we remember best the things that we learn when we are the most intensely conscious of the process, but the thing has not been thoroughly learned until we are

able to remember it with little or no consciousness. When the nervous impulse passes readily through the nervous arc, with little resistance, we remember it most easily, but there is little radiation and little consciousness. In the same way, the thing that we learn with expression, such as speaking, writing, drawing, etc., is likely to be best remembered, but it has not been thoroughly learned until it is possible to remember it without expression. Feeling consciousness and expression are all similarly related to the fact of resistance, and memory holds the same relation to all.

SIDELIGHTS

Memory is, as everybody says, on the bodily side, the reinstatement in the nervous centers of the processes in the original sensation, perception, etc.—*Baldwin, Methods and Processes, p. 280.*

The treatment of the centrally aroused ideas is rendered easier by the present-day assumption that memory images and the originally aroused sensations are of precisely the same character.—*Pillsbury, Attention, p. 95.*

The comparative feebleness of the remembered states or ideas is, we presume, the exact counterpart of the diminished force of the revived currents in the brain. It is seldom that the reinduced currents are equal in energy to those of direct stimulation at first hand.—*Bain, Mind and Body, p. 91.*

I think it can be shown that what the metaphysician calls consciousness (mind) are phenomena determined by the mechanism of associative memory.—*Loeb, Physiology of the Brain, p. 214.*

Mach has pointed out that the consciousness of the self or the ego is simply a phrase for the fact that certain constituents are constantly, or more frequently produced than others.—*Loeb, Physiology of the Brain, p. 214.*

Forgetfulness is one of the conditions of our mental life, and a *sine qua non* of its development.—*Lloyd Morgan, Comparative Psychology, p. 73.*

The faculty of forgetting details it is that makes retrospection possible.—*Lloyd Morgan, Comparative Psychology, p. 112.*

The capacity for self-education depends in great measure upon the power of exercising the art of oblivescence.—*Höffding, Psychology, p. 162.*

Every system of mnemonics deals with devices for learning things that are not worth learning.—*Bolton, Principles of Education, p. 395.*

Forgetting in many instances serves a useful purpose. * * * It is as necessary to know what to forget as what to remember.—*Colvin and Bagley, Human Behavior, p. 258.*

While as a rule recall is accompanied by recognition, recognition often takes place without recall.—*Colvin and Bagley, Human Behavior, p. 246.*

DEFINITIONS

Memory.—The reinstatement of a previous mental experience with the same conscious elements. The concomitant of the transmission of a nervous impulse through the same brain center that it passed through before, and the radiation out into the same fringing cells.

Mental Reproduction.—The reinstatement of a previous mental experience. The concomitant of the transmission of a nervous impulse through the same brain center that it passed through before.

Mental Recognition.—The reinstatement of the same conscious elements. The concomitant of the radiation out into the same fringing cells.

Law of Retroactive Inhibition.—A statement of the fact that if we turn immediately after having learned a thing to the study of something else we forget a large part of what we have learned in a few minutes after having learned it.

Law of Divided Repetition.—A statement of the fact that we can learn more in the same length of time if we divide the time that we spend into several periods separated by intervals.

CHAPTER XXII

Attention

A Double Process.—Attention was defined by the old psychologists as the power the mind has to turn all of its energy in one direction. We no longer speak of the power of the mind, and such a definition is unsatisfactory. Attention is a mental process, but we can best understand it by means of its physiological concomitant, if we can determine what that concomitant is. We may be quite safe in asserting that attention is the concomitant of the process by which a nervous impulse is directed into and through a brain center. But this is a double process, both phases of which are manifested in every act of attention. If we direct a nervous impulse into and through one brain center, we direct it away from and keep it from passing through another at the same time.

Depends Upon Resistance.—In order to direct a nervous impulse into and through a brain center, the resistance must be decreased between the center in which the nervous impulse is and the center into which it is to go; but at the same time, the resistance must be increased between the center in which the impulse is and the center into which it is not to go. The process by which the resistance is decreased is the concomitant of positive attention, and the process by which it is increased is the concomitant of negative attention. In every act of attention we have these two processes, of increasing the resistance in one place and decreasing it in another. At-

tention is a double process, and its physiological concomitant must manifest this same duplex character.

Definition.—We are now ready to make a satisfactory definition of positive and negative attention. Positive attention is the concomitant of the process by which the resistance is decreased between cells and centers, and negative attention is the concomitant of the process by which the resistance is increased between cells and centers.

Not Localized.—If our explanation of the general character of attention is at all plausible, it will be seen that there is no possibility of localizing the faculty of attention, or the process of attention in any portion of the brain. There is no such thing as an attention center, as there is a sight center or a hearing center, for attention is a process whose function is manifested in every center and between any two.

Method of Varying Resistance.—There are several suppositions that may be made concerning the nature of the process by which the resistance may be varied between cells and centers. We have already seen reason to believe that the resistance is encountered at the synapses, or points of junction of the neurons, where the nervous impulse leaves one neuron and enters another. We have spoken of the neuroglia as being an insulating substance, meaning that it offers more resistance to the passage of a nervous impulse than does the cell substance. Although difficult of demonstration, this is in all probability true. The problem then, of decreasing resistance depends upon varying the conductivity of that small portion of neuroglia which separates the terminations of the neurons from each other.

Change in Conductivity.—At least two methods are conceivable. We may suppose that the neuroglia

changes its conductivity at the point of nearest approach of the neurons, something as the insulating material of an electric circuit may have its conductivity increased by becoming wet. This is the hypothesis advanced by Sherrington, who conceives of the neuroglia surrounding the neuronic extensions as a synaptic membrane whose osmotic conductivity is variable and functional in only one direction. No supposition is advanced about the method by which the osmotic conductivity can be varied and the hypothesis seems less probable than the next to be considered.

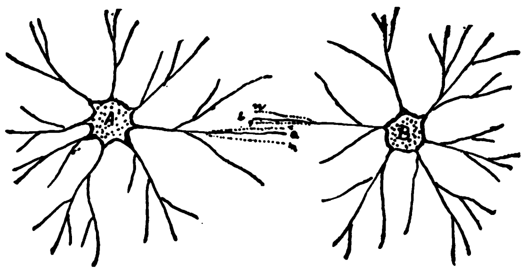

Fig. 38.—Diagram showing shifting of the dendrites at the synapse; a, b, normal position; x, y, positions in positive attention; m, n, positions in negative attention.

Shifting of the Dendrites.—Instead of this, we may suppose that the tips of the axonic and dendritic terminations of two cells may approximate each other more closely, so as to bring them into physiological communication although not likely into physical contact. This would be the condition of positive attention, while the wider separation of the tips of the dendrites would be the condition of negative attention. The shifting of the dendrites, then, either toward each other to accompany positive, or away from each other to accompany negative, would be the physiological concomitant of attention.

This second hypothesis is more easily understood, and will be adopted provisionally in these explanations. Whether this shifting of the dendrites is the actual process by which the resistance is increased or decreased or not cannot be positively affirmed, but the psychological facts that are observed would all be explained by the operation of the process.

Dendritic Movement Observed.—There is some evidence based upon the observations of Rabl-Ruckard, M. Duval and others, that the dendrites do shift their position. The principal value of their observation for us, however, is to demonstrate that there is such a possibility. The amount of movement observed by them would necessarily be altogether inadequate to account for such phenomena as we find manifested in attention. The phenomena of attention demand a quick movement throughout molecular distances so small as scarcely to come within the limit of microscopical observation. And the observations would have to be made upon some animal in which the attentive processes were as rapid as those of man, and in probably very few animals that could be observed do such processes occur. Hence it is very doubtful if the phenomena of movement that this theory demands could ever be observed. It is like the dance of atoms that no one has seen, but the phenomena that we can observe demand such a movement for their explanation.

Spontaneous Attention.—We may recognize two kinds of attention, spontaneous and voluntary. Spontaneous attention is that kind which we give without effort. There are certain things that it seems impossible not to attend to. If the teacher should stand on top of his desk and fire off a pistol, every pupil in the class would give undivided attention to the circumstance. If

the ceiling of the room should suddenly fall down, no one would be inattentive to it. If the partition of this room should suddenly rise and disclose an elaborate banquet, every student who lives in a boarding house would immediately be thoroughly attentive.

Established by Natural Selection.—This characteristic of spontaneous attention is a part of the human constitution. It is the only kind of attention that is possible to little children and other animals. It seems to have been fixed in the constitution of animals by the process of natural selection. The things that are attended to spontaneously are the indications of food and the presence of danger, or strange and unusual things, which are generally dangerous. In times of scarcity of food, those animals that attended most successfully and with least effort to the indications of food would be the ones that survived, while those that failed to attend would perish. Likewise, if we imagine two animals, or young children playing on a railroad track while a train was approaching, the one who attended to the danger would in all probability escape, while the one that failed to attend would be killed and leave no descendants to inherit the same inability to attend. Ultimately, the characteristic of giving attention to dangerous, or to strange and unusual circumstances, or to the signs of the presence of enemies and indications of food would become universal.

Voluntary Attention.—But there is another kind of attention which we may call voluntary. This is the kind that we give to the study of our lesson when there is a circus parade, or a monkey and a hand organ outside. We know that we are able to attend to the study of our lesson under distracting circumstances, but it requires an effort to do so. This kind of attention is always accompanied by a feeling of effort, and always, or nearly

always, by some kind of muscular movement. The muscular movement is the particular feature of the process from which the name attention is derived.

Voluntary Attention and Education.—It is through the process of voluntary attention that we become educated, and the ability to give voluntary attention for continued periods of time is a mark of education. We may state the entire process of education in terms of attention. When a particular form of activity or a particular subject ceases to demand effortful attention, it is no longer educative. When we learned the alphabet, or the multiplication table, it was an educative process, but when these two subjects became mechanical, and could be recited without effort of attention, their repetition was no longer educative. Only those animals can be educated, in any true sense of the word, that are able to give voluntary attention.

Origin of the Feeling of Effort.—It is necessary to consider what is the source of the feeling of effort which is the most characteristic feature of the process. Many persons, impressed with the prevalence of muscular contraction in attention, have recognized the muscular contractions as the source of the feeling of effort. In fact, some psychologists have insisted that the muscular contraction is the attention. Ribot believes that the feeling of effort arises from the contraction of the muscle that wrinkles the forehead, and Mr. James says that whenever we attend to anything, we are conscious of the movement of something in the head.

Not Due to Muscular Contraction.—But we may experience the feeling of effort when there is no movement of the muscle. In cases where the nerve has been cut, or paralyzed from some other cause, there is as truly a feeling of effort as if the nerve were functional and the

muscle contracting. It appears then, that the feeling of effort has its origin in the head, but on the inside, in the brain, rather than on the outside, in the muscle. We may associate it with the shifting of the dendrites.

Origin of the Movement.—Although it is impossible for us to agree to the conclusion that the contraction of the muscle is the attention, it is necessary to inquire what is the origin and meaning of the muscular movement which so commonly accompanies attention. When we experience the feeling of effort involved in the shifting of the dendrites, it is evidence that there is considerable resistance encountered by the impulse. Considerable feeling is experienced also, for the process of attending voluntarily is not pleasant, but rather a painful process. When the resistance is encountered, the nervous impulse runs out into the centers most easy of access which are usually the motor centers, and the movement follows.

Attention and Intellect.—We are now ready to understand the relation of attention to the intellectual process, which may be nicely illustrated by tracing its effects upon perception. In general, the effect of attention is to heighten perception. We may hear a clock tick at a distance of one hundred feet, when under the same conditions we are unable to hear it at a distance of ten feet when we do not attend.

Explanation of Increased Sensitiveness.—The means by which this result is attained seems to be as follows: When I am attending to the ticking of the clock, I think or imagine how the ticking will sound. This means that I am setting the dendrites in the clock-ticking center in such a way that the nervous impulse will pass through them most readily. If I have heard the clock tick before, I am already sending a centrally initiated impulse through the same clock-ticking center, so that it requires

a very slight peripherally initiated impulse joined with the centrally initiated impulse already passing through it, to increase the vividness of the experience to the intensity of a percept.

Search for Lost Article.—So when a boy loses a knife or a ball, he throws a similar ball or knife down in a locality in which he supposes he lost it. He explains the success of this method of search by the hypothesis that the second ball or knife draws the first to it. Really, the second ball or knife enables him to establish a vivid impulse in the ball or knife center, so that he knows exactly how the lost article will look, and a very slight peripherally initiated impulse will enable him to discover the object.

Law of Dynamogenesis.—This explanation shows us also, why an idea that we hold before our minds tends to work itself out into action. It lies at the foundation of that profound psychological principle that we shall study under the name of the Law of Dynamogenesis. It shows us also why we can see a thing so much better if we know what to look for, and why it is difficult to see a thing that we are not expecting to find.

Hypnotism.—This explanation of the power of attention to heighten perception accounts for many of the phenomena of hypnotism. Hypnotism may be explained as a case of perfect attention, which is the explanation proposed by James Braid, its founder. This explanation has been criticised severely, but not in the light of this brain cell movement theory of attention. Some of the most astonishing phenomena of hypnotism are explainable upon the supposition that the activity of the senses is enormously intensified. In one case, in which the hypnotized person stood in front of another who was holding a book, the hypnotized person was able to read off

the words that the other person saw. Immediately the hypothesis was proposed that there was a mysterious transference of thought, but it was positively proved that the hypnotized person was reading the reflection of the words from the cornea of the other person's eye. (See James, Psychology, v. 2, p. 609.) Similarly a hypnotized person may be able to hear a watch tick when it is in a distant room in another person's pocket.

Intellect Varies Directly as Attention.—Since attention directs a nervous impulse through the brain center, and the amount of intellectual work that can be done is the concomitant of the amount that goes through, it is readily understood that with a given amount of nervous energy, the intellectual work will vary with the attention, and the more successful the attention the greater the amount of work than can be done.

Attention and Feeling.—Positive attention decreases the resistance that is encountered in a nervous arc, or a brain center, while negative attention increases it. Since resistance is the concomitant of feeling, it will be readily understood that feeling may be increased or diminished by a process of attention. We may attend to an ache or a pain in such a way as to cause it to disappear. This is the secret of all faith cures, or mind cures or miracle healing or Christian Science. The various formulae recited, or recommended by the miracle worker, and mysteries and mummeries with which the processes are surrounded are merely devices by which the proper kind of attention may be induced.

Hysteria and Worry.—By negative attention we may increase the resistance and increase the feeling, even to the point of great pain. A disease may be induced in this way, and probably half of all our cases of disease have more or less of this element of hysteria in them. When

the disease and its accompanying painful feeling is the result of negative attention, the only thing necessary to cure the disease is proper positive attention. The general name for such disease is hysteria, which may simulate almost any form of organic trouble with which the patient is already acquainted, and it is almost impossible to distinguish it from the real organic disease by the methods of ordinary diagnosis. In a milder form it is called worry, which may be described as the condition of continued negative attention.

Experiment in Attention.—If a person will look steadily at the end of his finger for a minute, thinking of it all the time, he will begin to experience a very peculiar feeling in that spot. Under extraordinary conditions a blister may even be produced by the touch of a pencil point. If we look steadily at any single letter or figure in the page of a book, we shall soon begin to feel that that letter is the queerest and most peculiar letter ever printed.

Mental Healing.—When a disease is of this kind, superinduced by negative attention, the only thing necessary to cure the disease is to give proper, positive attention to it. But there are diseases that are not the result of negative attention, and positive attention will not cure them. Attention will not heal a broken arm, nor a ruptured artery, nor destroy the bacillus of tuberculosis. However, even in cases of genuine lesion of the tissues, positive attention may diminish the pain, or cause it entirely to disappear. The danger is then that the person believes the disease is cured, and may die the next day. Almost the only test that faith healers apply is the removal of pain. But pain is only a symptom, and not the disease itself. In such cases, the removal of the pain may be an injury instead of a benefit. It corresponds to the

use of morphine or cocaine. It is like covering the crack in a broken beam with paint.

Attention and Consciousness.—The relation of attention to consciousness is easily stated, although in consequence of the duplex character of attention, its manifestations are complex. We can by a process of positive attention diminish the intensity of consciousness. This is the condition in which we are so much absorbed in our work that we are slightly conscious of other events that occur near us, and are scarcely aware of what we ourselves are doing. The typical cases of absent-mindedness are of this kind. The absent-minded man is so intensely attentive to his own thoughts that he is scarcely conscious of circumstances that might be expected to influence his actions.

Unconsciousness from Negative Attention.—On the other hand, by a process of negative attention we may become conscious of things that ordinarily we do unconsciously. We may make ourselves conscious of the movement of the organs in speech, or the muscular movement in running, and by a process of attention we may become conscious of the beating of the heart and the contact of our clothes with our body. The effect of positive attention is in general to diminish consciousness, and of negative attention to intensify it. But in extreme cases, negative attention may throw so much resistance into the circuit that it breaks the current, and unconsciousness follows. This is the condition that is sometimes called fainting from excess of emotion.

Chloroform.—The unconsciousness resulting from the administration of chloroform, although not a process of attention, involves the same mechanism. Each neuron may be considered as homologous to a single animal cell, and likened to an amoeba with enormously attenuated

pseudopodia. If a drop of chloroform, or chloroform vapor is introduced into the water surrounding an amoeba, all the pseudopodia at once contract. When a person breathes the vapor of chloroform, it is taken from the lungs into the blood, carried to the brain, affects the neurons, causing all the dendrites to retract and shrink away from each other, increasing the resistance to such an extent that the nervous impulse is unable to pass through the brain center, or to radiate out of it, and unconsciousness follows.

Attention and Memory.—The relation of attention to memory is easily understood. Positive attention diminishes the resistance in a brain center, permitting a larger amount of nervous energy to pass through it, and consequently modifying the nervous arc more than would otherwise be done. Hence the nervous impulse more easily retraverses the same arc, and memory is more successful. The more nearly perfect attention becomes in the process of learning, the better we shall remember. It attention were perfect in learning anything, the probability is that we should not forget what we have learned.

Attention and Nervous Energy.—Attention is weakened if the amount of nervous energy is diminished. We must make a greater effort to attend if we are sick or feeling bad or out of sorts. We may understand this effect if we consider that a strong nervous impulse will pass over a larger synaptic space than a weaker one will. Hence when the amount of nervous energy is small, we shall need to bring the dendrites closer together, necessitating a greater effort.

Pulsation of Attention.—It is impossible to attend to one thing, or to one aspect of a thing for a very long time. About three-fifths of a second is the average length of time before the attention shifts, although in extreme

cases six seconds or even twelve seconds have been reported as the result of experiments. It is the amount of time that the isomeric changes from colloidal to crystalloidal can occur without an interval of rest.

Active and Passive Attention.—Voluntary attention, accompanied by a feeling of effort, is sometimes called active attention. As the process of transmission through any nervous arc becomes habitual, it is attended with less effort until all feeling of effort seems to disappear. The attention that is involved in such transmission is then sometimes called secondary passive, from its resemblance to spontaneous attention, which is sometimes called passive attention. These terms passive, active and secondary passive are employed by some psychologists, but they are not to be commended.

SIDELIGHTS

The most important thing for us is to see that attention is nothing more than the interaction of different nerve cells and experiences in the control of other nerve cells and experiences.—*Pillsbury, Attention, p. 306.*

If the neurons are fixed, they are necessarily immobile. If they are free from attachment, they are capable of receding and approaching each other under conditions that are not yet ascertained.—*Morat, Physiology of the Nervous System, p. 23.*

The suggestion has been made that in some cases the space between two neurons may be varied by amoeboid movements of the dendrites and terminals of the elements concerned. Although much may be said in favor of this hypothesis, good histological evidence is yet wanting.—*American Text Book, Volume II, p. 207.*

Amoeboid movements of the dendrites were first described by Rabl-Ruckard.—*Wundt, Physiological Psychology, p. 54.*

In the first place, the acts of attending, negating, assenting, making an effort, are felt as movements of something in the head. —*James, Psychology, Volume I, p. 300.*

Duval asks if we must not admit that the cerebral neuron and its ramifications are not always comparable to an amoeba with its pseudopodia, these ramifications retracting under various influences and so producing more or less intimate contiguity of the cerebral neurons.—*Manaceine, Sleep, p. 52.*

Nevertheless, as mechanical phenomena, properly so called, are those which are most easily comprehended, as they are those which in the study of any function have always contributed to furnish the first intelligible ideas, the doctrine of amoebism (dendritic movement) by clearly defining the connection between nerve elements indicates progress in the study of nerve physiology.—*Morat, p. 26.*

Cajal regards the neuroglia as possessed of amoeboid characters, by virtue of which it is enabled to act as an isolator of nervous currents.—*Manaceine, p. 53.*

Growth of mind and brain power shows itself most clearly in increased power of attention.—*Höffding, Psychology, p. 160.*

Again we see that pathological facts compel us to assign attention to the frontal lobes.—*Pillsbury, Attention, p. 254.*

Intellectual Education is fundamentally a developing of the attention.—*Stanley, Evolutionary Psychology of Feeling, p. 242.*

Negative attention is then, I think, a real activity, a will force, which directly hinders and crushes out the unwelcome in consciousness, while positive attention is will force vitalizing and strengthening the pleasant.—*Stanley, Evolutionary Psychology of Feeling, p. 240.*

The details of the mechanism of the synapse are still altogether lacking, although numerous theories have been developed to explain it. * * * The older, and in many ways the simpler, regards the neurons as living organisms that still possess at their extremities the power of motion inherent in their amoeba-like prototype.—*Pillsbury, Essentials of Psychology, p. 50.*

It is popularly believed that the degree of attention depends upon and varies with the amount of muscular strain, exertion, effort that accompanies the attentive process. * * * Now the fact is that while this relation holds in rare cases, the consciousness of strain, effort (muscular), usually indicates a low degree of attention. Ordinarily, maximal attention is marked by the absence or obscurity of the feeling of effort (muscular).—*Major, Psychology, p. 178.*

DEFINITIONS

Attention.—The psychological concomitant of the process by which a nervous impulse is directed into and through a brain center.

Positive Attention.—That kind of attention by which the resistance between cells and centers is decreased.

Negative Attention.—That kind of attention in which the resistance between cells and centers is increased.

Spontaneous Attention.—That kind of attention that is accomplished without effort.

Voluntary Attention.—That kind of attention that is accompanied by a feeling of effort.

CHAPTER XXIII

Will

Phenomena of Will.—That there is a phenomenon of mental life called will, which every one recognizes as a constituent element in his own experience, no one will deny. That its nature is very complex and difficult to conceive in any way is equally evident. That most of the discussions of will have involved inconceivable propositions and have been largely beside the question, is quite as demonstrable. So difficult are the problems involved in the discussion of the will that many psychologists refuse to consider it under that head, and treat of action instead. The reason adduced for this procedure is that every act of the will must eventuate in some kind of muscular contraction. Hence a study of the will is nothing more than a study of the kinds of actions that muscular contraction produces.

Not Necessarily Motor.—It would seem that this proposition is scarcely demonstrable. It is as truly an act of the will sometimes to refrain from making a muscular movement as it is to move. It is as truly an act of the will to keep an idea before the mind and to think about a certain thing as it is to contract a muscle. There are no muscular contractions in the internal direction of a train of thought. The movement theory of will implies that in order to become an act of the will, a nervous impulse must enter, pass through and leave a brain center, but it must leave by way of a motor center. But it appears to be quite as satisfactory interpretation of the

facts, if instead of passing into a motor center, the nervous impulse should pass into a center of some other kind.

Former Notions About Will.—To the older psychologists, will was a simple matter. It was merely a self determination of the substantial entity called mind, or the ego, and was conditioned by no necessary laws. The self activity of the mind and its self determination was will. "The will determined itself." It was not necessarily determined by anything else. It was a fundamental power of the mind, and no other explanation was necessary nor possible.

Feelings Determine the Will.—But even among the older psychologists there were those who regarded any decision made by the will as determined by the feelings. It was a common expression that feelings formed the will. By this was meant that the actions of a person were determined by the will in accordance with the feelings. If one kind of feeling was experienced, the will acted of its own accord in one way; if another kind of feeling was experienced, the will acted in another way although if it had been so disposed it might have acted differently. This is merely another statement of the proposition that feelings are the motive powers and lead to action; that feelings determine what the action shall be, whether it is of a mental or a physical character.

Ideas Determine the Will.—In opposition to this at the present time the opinion is widely prevalent that it is the intellectual idea that works itself out into action, and determines what the action shall be. This is the law of dynamogenesis, and it seems to be supported by satisfactory observations. Either position may be defended by observations that all will acknowledge to be true, but this merely shows the complexity of the phenomena

grouped together as will, and the inadequacy of the theory of will as at present understood.

Identity of Will and Other Processes.—So we find that different writers at various times have considered will and feeling as identical; others have believed the same thing of will and intellect, will and consciousness, will and attention, and will and expression, or action. It will be seen that a comprehensive theory of will which shall coördinate all the facts whose partial consideration has led to such diverse interpretations is badly needed.

A Double Process.—Will is a double process, and one of its elements is the process of attention which has already been discussed. But there is a second element of the will that has been overlooked. We can best make clear what this element is by a résumé of the propositions that have been advanced in the preceding chapters.

Elements of a Current.—In every current, there are certain elements which are necessary to constitute it a current. The elements that are common to all currents will very likely indicate the essential components, while those characters that are peculiar to the individual currents will be left out of the number that enter into the conception of currents in general.

Concomitants of Current Elements.—We have assumed that all the psychological processes that can be discriminated from each other have their physiological concomitants in the elements of a current. It will help us very much to determine what the essential elements of a current are.

The Conductor.—Every current must have some kind of a conductor. In the case of a river current, the river bed itself is the conductor. In the electric current, the conductor is usually a wire. In a nervous current, the conductor is a nervous arc, which in its simplest form

consists of a nerve, two ganglion cells, and another nerve.

The Insulator.—Every current must have some kind of an insulator for the conductor, or some method by which the current is kept from leaving it. In the case of the river, the banks serve the function of an insulator; in the electric current, the insulator is a covering over the wire, or it may be that the air itself serves as the insulating material. In the case of the nervous current, we have assumed that the neuroglia, and along the course of the nerve, the medullary sheath serves the function of the insulator. It will be seen that neither the conductor nor the insulator has any psychological concomitant.

Resistance.—Every current encounters some resistance. In the river current the resistance is the friction of the water against the banks, the inequalities in the river bed, or obstructions that it meets. The effect of the resistance is to delay the current, and to warm the water in the river. In the electric current, the resistance is called merely resistance, and we measure it in ohms. The effect of the resistance is to produce heat. In the nervous current the resistance has no other name. We are unable to measure its amount, although we detect it by means of the chronoscope, and its psychological concomitant is feeling.

Field of Influence.—Every current produces some effect upon the bodies in the space near it. We may call this space in which it produces the effect the field of influence. In the case of the river current, the field of influence is indicated by the water that is drawn by capillarity out of the river into the soil along its banks. Also it is shown by the current of air that is dragged along by the surface of the water. In the electric current the field of influence is called the magnetic field, and it is mapped

with a magnetic needle. In the case of the nervous current, the field of influence is the radiation of the nervous impulse out of the brain center into the fringing cells, and its psychological concomitant is consciousness.

Work Done.—Every current is capable of doing some work. In the river, the work may take the form of driving water wheels and turning machinery. It is measured in foot pounds and horse power. In the electric current the work done is the turning of motors and driving machinery. In the nervous current the physiological work is the transmission of a nervous impulse through a nervous arc, and its psychological concomitant is intellectual work, such as solving problems, memorizing, perceiving, etc.

Direction of Current.—Every current is directed by changing the degree of resistance to be overcome, making it greater in one path than in another. In the river current, it is directed by dams and gates. In the electric current by switches and shunts. In the nervous current by the shifting of dendrites, and the psychological concomitant is attention.

Driving Force.—Every current must have some kind of driving force. In the river current, this is provided by the fall of the river, or in the case of water wheels the force of the water is the difference in level between the water above the dam and the water below, which is called the head. In the electric current the driving force is called the electro-motive force, and is measured in volts. In the nervous current we have no means of measuring it, and no name for the force. The fact that there is a current is well recognized, but its driving force has not been considered. It is in some way connected with the oxidation of tissue, and after the analogy of the electric current, I propose to call it the nervo-motive

force. It is this nervo-motive force that appears to be the concomitant of will, or its concomitant, the second element in the constitution of the will.

TABLE 1

	River	Electric	Nervous	
			Physiological. Current	Psychologic. Psychon
Conductor	Bed	Wire	Nervous Arc	
Insulator	Banks	Cotton Covering	Neuroglia	
Resistance	Friction	Resistance	Resistance	Feeling
Field of Influence	Capillary Water Air Currents	Magnetic field	Radiation	Consciousness
Work Done	Water Wheels	Motors	Transmission	Intellectual Work
Directed by	Dams and Gates	Switches and Shunts	Shifting of the Dendrites	Attention
Driving Force	Fall. Head	Electro-motive Force	Nervo-motive Force	Will

The Psychon.—We have thus described the elements of the nervous current and have determined the psychological concomitant of each. As we have one word, cur-

TABLE 2

$$\text{Will}\left\{\begin{array}{l}\text{Concomitant of}\\ \text{Nervo-Motive Force}\\ \\ \text{Attention}\left\{\begin{array}{l}\text{Positive}\\ \\ \text{Negative}\end{array}\right.\end{array}\right.$$

rent, to express the sum of all the elements, so we need one word to express the sum of all the psychological concomitants. Mind and consciousness are both unsatisfactory, and I propose to coin a new word to fit the new

conception in psychology and call the combination of the psychological concomitants of the current elements—intellect, consciousness, feeling, attention, will — the psychon. It will be found very convenient to speak of the different elements of the psychon, instead of the different states of consciousness.

Evidence of the Hypothesis.—In order to establish the validity of the determination of will as the concomitant of nervo-motive force, we shall need to demonstrate, first, that there is a nervo-motive force, and second, we shall need to present evidence in favor of the assumption that this force is the concomitant of will.

Existence of the Current.—The best evidence of the existence of nervo-motive force is the existence of the current itself. By current we mean the change in successive molecules of the nervous arc. No one will deny the existence of the current, and no one will believe that it will flow and that successive molecules will change without the manifestation of some force. The nature of the force is beyond our knowledge, and perhaps beyond our comprehension. Whether it is some form of energy similar to those already described in textbooks on physics, or identical with one of them, or whether it is different from any that is there recognized is beyond our province to discuss. Whether it is capable of being transformed into one of the recognized forces, and has a quantitative relation to them, is also beside our present question. But that there is a force, the fact of a current abundantly proves.

Oxidation of Brain Tissue.—Another evidence of the existence of a nervo-motive force is found in the fact that brain tissue is oxidized, and the resulting products have a lower degree of complexity than those which are destroyed. Whenever substances undergo a chemical

change resulting in the production of substances of a lower degree of complexity, energy is liberated. The change is a katabolic change, and results in the liberation of energy.

Interruption of Mental Processes.—In the next place, we find that all mental processes stop almost instantly and nervous currents cease to flow, when the conditions for this chemical action in the brain are not present. Pressure on the carotid arteries results in unconsciousness in thirty seconds. Hemorrhage produces fainting. The brain weighs only one-fiftieth of the weight of the body, but it draws usually from one-twelfth to one-eighth of the blood. It is not necessary, however, to shut off the supply of blood in order to stop mental action. All that is necessary is to shut off the supply of oxygen to the brain, and this may be done by cutting off the supply of oxygen to the blood. The blood may continue to flow, but if the person is in an atmosphere that contains little oxygen, the same results follow as if the blood were cut off. More than this, we find that when severe mental work is accomplished, there is a greater amount of katabolic substances produced in the brain and excreted from the system.

Concomitant Variation.—The evidence for the concomitance of will and nervo-motive force is found principally in the fact that the two vary together constantly. When we are able to make proper allowance for all modifications of the nerve current that arise from variation in resistance, character and modifications of brain tissue and the substance of the nervous arc, and for the effect of habit and attention, we shall always find that strength of will varies directly as the amount of nervous energy liberated. The facts that constitute this evidence may be grouped under three heads.

Pathological Will.—The first group of facts are those that are derived from an examination of pathological conditions of will. We find in every case of weakened will, that the bodily conditions are such as to diminish the amount of tissue oxidized in the brain. Some of these pathological conditions are cases of habitual users of alcohol, morphine, opium, cocaine. In every case, the formation of the habit of this kind results in a condition of weakened will. Why does not the drunkard, or morphine eater discontinue the habit? Every one not so addicted is sure that he himself could quit under similar circumstances, so why does not the drunkard? But with his weakened will, the breaking of the habit is a chemical impossibility.

Diminished Nervo-Motive Force.—Indulgence in a narcotic habit always results in lessened oxidation in the brain. The entire range of metabolic processes in the body is circumscribed, and this can usually be recognized in the paler complexion, due to the lessened number of red blood corpuscles, which are the carriers of oxygen; the loss of appetite; in the sluggishness of the circulation, and in fact, in almost all the processes that we have found to be essential to the liberation of nervous energy.

Drunkard's Red Nose.—Even the red nose of the drunkard is an indication of lessened nervous energy. The nose is red because a diminished supply of nervous energy is transmitted to the muscles that keep the arterioles tense and of their proper size. When the nervous supply to the muscles is diminished, the muscles relax, and the little arteries enlarge.

Indications of Weak Will.—The man whose will is weak from narcotics or sickness or any other cause is unable to carry on his work and to do the things that he

knows he ought to do even if it is his customary and habitual occupation. Still less is he able to undertake any new work, or devise new processes of accomplishing the old. We have a classical example of this weakness of the will from the use of opium in DeQuincey. He tells us that when he was addicted to the use of opium, letters would lie for months unanswered. He knew that that they should be answered, knew exactly what to say, but could not bring himself to answer them. His will was weak.

Treatment of Weak Will.—Many of us have unanswered letters, or some unfinished work that corresponds to them, and the cause is the same. Our wills are temporarily weak, not perhaps from indulgence in opium, but from other causes. In such a case, when we feel disinclined to work and to do what we know we ought to do, the only proper thing is to do something that will enable us to generate more nervous energy. We need to take a vigorous walk, to start the blood to moving more rapidly to the brain, to breathe more fresh air so as to oxygenate the blood. In this way by generating more energy, we strengthen our will. It is a common experience that at the beginning of exercise or many other kinds of work we feel much disinclined to do it, but as we continue, the circulation quickens, more nervous energy is liberated, and we find it pleasurable.

Treatment of Narcotic Habit.—The proper treatment of a narcotic habit is indicated by its effect. The treatment is to do anything that will cause more nervous energy to be liberated. Good food, pure air, sufficient exercise to quicken the circulation, but not enough to produce fatigue; and it may be necessary, although this condition is secondary, to discontinue the use of the drug. But the discontinuance of the drug without the other

conditions to increase the nervous energy generated will result in disappointment. Anything that will cause more energy to be liberated will strengthen the will. Some cases of weakened will do not arise from narcotic habits. Many examples are given by Ribot in his Diseases of the Will.

Weakened Will From Starving.—When one is fasting or starving for several days, the most noticeable persistent psychological symptom is a weakness of will. Nothing can be undertaken that is not done by the force of habit. Notes of the psychological condition of a man completely abstaining from food for seven days continually emphasize the facts of weakness of will. When food is lacking to repair the tissues, oxidation cannot proceed with its usual rapidity, and less energy is liberated.

Evidence From Sensation.—Another line of evidence is derived from the fact that sensations are diminished in intensity in cases of weakened will. The senses are not so acute nor the sensations so vivid when the will is weak. Not so small difference in touch, sight, color, nor hearing can be perceived as when the will is of its normal strength. If the amount of nervous energy available for psychological purposes at any time is less than the usual amount, the impulses originating in the sense organs will be less than they usually are, and we shall be able to experience sensations of less than the ordinary degree of intensity. Intensity of sensation depends upon the amount of nervous energy that is manifested in the nervous impulse. The weakened will is accompanied by a diminished intensity of sensation. The conclusion is that since we know that the diminished amount of nervous energy is the cause of the diminished intensity of sensation, and diminished intensity of sensation al-

ways accompanies weakened will, the weakened will must also be related to the diminished amount of nervous energy.

Function of Attention in Will.—The nervous energy that is liberated in the brain must be gathered up and transmitted through a brain center before it is available for intellectual work. It is like the generation of electricity upon the plates of a battery, but no work can be done by the electricity until it has been gathered up and a circuit established through a wire connecting the plates. The energy liberated in the brain cells is the nervo-motive force, but the energy is gathered up and directed through a nervous arc by a process of attention. Hence we find that nervo-motive force, and attention, both positive and negative, constitute the concomitant of will.

Will and Feeling.—Since feeling depends in part upon the amount of nervous energy, or strength of the current, we shall expect to find feeling and will varying with each other. In general this is true, although other circumstances may sometimes prevent a recognition of the fact, and the other condition of resistance, the nature of the nervous arc, will always explain the contradictory instances. It is on account of this fact that many persons believe will is identical with feeling, or that the feelings form the will, and are the motive powers.

Will and Intellect.—In general, also, the man of strong will is a leader of men, and capable of greater intellectual work. If the will is weakened from any cause, the intellectual ability is decreased. So we are unable to accomplish our work when we are sick, not primarily in consequence of lack of muscular power, or any other imperatively inhibiting cause, but primarily because our will is weak.

Will and the Law of Dynamogenesis.—This view of will is quite different from the one that asserts that will is capable of deciding upon any line of action and then pursuing it. No act of any kind can be willed except by entertaining a clear idea of the action, and a clear idea demands the transmission of a strong impulse through a brain center. The act of the will really consists in transmitting an impulse through the center. No act can be willed that has not been previously experienced. This in itself is sufficient to necessitate a new interpretation of will.

SIDELIGHTS

For a long time any explanation of the phenomena of organic life by means of the general forces of nature was regarded as materialism.—*Höffding, Psychology, p. 33.*

In the case of willed movement, this voluntary enforcement depends upon the amount of free energy in the brain at the moment. —*McDougall, Physiological Psychology, p. 166.*

The will of the metaphysicians, then, is clearly the outcome of an illusion due to the necessary incompleteness of self-observation. —*Loeb, Physiology of the Brain, p. 216.*

The fondness of these writers, and of popular thought, for the term will, or activity, with the implication of something beyond consciousness, seems to be rooted in the anthropomorphic tendencies of the human mind.—*Pillsbury, Attention, p. 290.*

There are large numbers of intelligent persons who rather pride themselves upon their fixed belief that our volitions have no cause, or that the will causes itself, which is either the same thing or a contradiction in terms.—*Huxley, Hume, p. 145.*

Will is not an independent thing; it is merely the control of action by ideas.—*Irving Miller, Psychology of Thinking, p. 64.*

The other theory, that consciousness makes adjustments, and modifies structures directly by its fiat, is contradicted by the psychology of voluntary movement. Consciousness can bring about no movement without having first an adequate experience of that movement to serve on occasion as a stimulus to the innervation of the appropriate nerve centers. This point is no longer subject to dispute. —*Baldwin, Development and Evolution, p. 113.*

Wundt has shown that will and attention are intimately related, and has employed the term apperception to denote their common constituent.—*Külpe, Psychology, p. 214.*

The nervous system contains in its various parts stores of potential energy which may be liberated in large quantities by very small excitations.—*McDougall, Body and Mind, p. 108.*

A like one-sidedness is shown in the constant insistence upon the reflex arc as the functional unit of the nervous system. It seems to be forgotten that from another point of view, the office of the cortex may properly be described as the interposition of resistance between sensory stimulus and motor response.—*Titchener, Psychology of Feeling and Attention, p. 310.*

Diseases of the will are usually resultants of depleted nervous energy.—*Bolton, Principles of Education, p. 267.*

As I regard the case, the palsied nerves, the exhausting struggle, and the indifferent execution are all signs of diseased, and therefore weak, will.—*Bolton, p. 714.*

The perfect control without struggle, and accurate execution are evidences of strength of will in that direction. Whatever is voluntarily done with ease and accuracy is a manifestation of strong will.—*Bolton, p. 714.*

DEFINITIONS

Will.—The concomitant of nervo-motive force directed by attention, both positive and negative.

Nervo-motive force.—Nervous energy liberated by the oxidation of brain tissue. The force that drives a nervous impulse through a nervous arc.

Law of Dynamogenesis.—A statement of the fact that an idea clearly entertained will work itself out into action.

Psychon.—The entire concomitant of a nervous current. The sum of all the psychological processes which are the concomitants of the current elements.

CHAPTER XXIV

Forms of Action

Why Consider Action?—Instead of discussing will as a mental process, many psychologists discuss action instead; or discuss will in terms of action. The theory upon which this treatment of will is based is that every act of the will must eventuate in some muscular contraction. The impulse must start in some sense organ, pass through a brain center and run out into some muscle before it can constitute an act of the will, or be the concomitant of a mental process. This theory is sometimes described as the sensori-motor arc conception. It appears to be incapable of demonstration, and is in fact too limited a view of the relation between mental processes and the nervous impulse. We may agree fully with the proposition that a nervous impulse must enter, pass through and leave the brain center in order to constitute the concomitant of a mental process; but that it must originate in a sense organ is undemonstrable, and that it must pass into a motor center is likewise unnecessary. Many impulses do originate in a sense organ, but many others are centrally initiated. Many impulses do pass into a motor center, but many do not; and many of those which do, bring about actions which are the expressions of feeling, and are more or less accidental and superfluous.

Reflex Movement.—If you are sitting with your knees crossed, and strike the patella a sharp blow with your knuckles, your foot will move. This is a reflex act, and is

not willed, nor in fact can it be prevented. The foot moves of itself. A nervous impulse is started by the blow of the knuckles in a nerve under the patella, is carried to the spinal cord, and passes back to the muscle that moves the foot over a motor nerve, but does not reach the cerebral cortex. Other examples of reflexes are found in the contraction of the muscles that control the size of the pupil of the eye, in the movements of the digestive organs, and in many other parts of the body.

Other Reflexes.—But reflex movements are not limited to the human body. If we observe an amoeba or a vorticella or other one-celled animal under the microscope, we shall see it make movements adjusting it to the conditions in which it finds itself. It will send out pseudopodia, and when it comes into contact with other objects will retract them. These movements are reflexes. Similarly, a sensitive plant will fold its leaflets and drop its leaves at a slight touch. Other plants will do the same in a less degree, and in fact the same kind of movement will be found universal in the animal and plant kingdoms, wherever there is protoplasm manifesting its activity.

A Direct Response to a Stimulus.—If we observe the movement of the protoplasm in the leaf cells of Elodea, we shall find it move more and more rapidly under the stimulus of heat. A sharp blow on the stage of the microscope will immediately stop the movement. So wherever we find protoplasm, we shall find it responding to stimuli, sometimes by movement, sometimes by cessation of movement, and this direct response of protoplasm to a stimulus constitutes the reflex action.

Direct and Indirect Application of the Stimulus.—In case of the amoeba and the sensitive plant, the stimulus is applied directly to the protoplasm itself. In case of the knee jerk, the stimulus is applied to the protoplasm of

the nerve, but it reaches the protoplasm of the contracting muscle indirectly by means of the nerve. The same application of force to the muscle would produce movement, but it is distributed more efficiently to the muscle by the nerve than it could be directly by the mechanical shock.

Three Kinds of Reflexes.—We shall be able then to discover three kinds of reflex action: First, the kind in which the stimulus is applied directly to the protoplasm, as in case of the amoeba and the sensitive plant. Second, that in which the stimulus is applied to the motor nerve leading to the muscle. And third, that in which the stimulus is applied to the sensory nerve, is carried to the ganglion, or reflex center, and thence sent back to the muscle by means of the motor nerve. It is this third kind of movement from which the word reflex is derived, and sometimes the word is limited to this kind of movement. The thought is that the stimulus is reflected from the spinal cord, and thrown back as a ball is reflected from a wall. It appears, however, that this is too limited a meaning for the term, and that there is no essential difference in the three kinds, except that the nerve is connected with the different fibers of the muscle in such a way that the stimulus can be applied to all of them at once more effectively through the nerve than it can be directly.

The Nerve-Muscle Machine.—A stimulus so slight that it would not affect a muscle if applied to it directly, will be appreciated by a nerve; and when transmitted by the nerve to a muscle will bring about a contraction incomparably greater than would be manifested in the protoplasm of the nerve, or in the undifferentiated protoplasm of the amoeba. The combination of nerve and muscle constitutes a nerve-muscle machine which has

the effect of intensifying both the stimulus and the movement.

No Mental Process Involved.—So far as the contraction of a muscle is concerned, every muscular contraction is a reflex. It is the direct response of the muscular protoplasm to the stimulus transmitted to it by the motor nerve. There is no mental process about it, and we shall need to look in some other place for the distinction between reflex and any other kind of action.

Automatic Action.—The beating of the heart and the movement of the lungs in breathing represent another kind of action which is called automatic. It is sometimes described as the most reflex of all the reflexes, and the description is fairly appropriate. The difference between reflex and automatic is not in the kind of movement but in the regularity. Automatic actions are rhythmical, occurring at regular intervals, while reflexes occur at any time that the stimulus is applied. Otherwise we may consider the two as identical.

Reflex Movements of a Baby.—The first movements of a baby are all of them reflex. If a brightly colored ball or other conspicuous object be held in front of a baby from three to six months old, the sense impression produced by it establishes in him a series of reflexes. If a sufficient supply of nervous energy is available, he will respond by a movement of his hands, his feet, his head and his whole body. It is the undirected overflow of nervous energy into the motor area and the entire series of reflex movements results.

Functional Selection.—None of these movements are purposeful, or directed toward grasping the ball. But some of these purposeless reflexes may bring the hand of the child into contact with the ball, when the stimulus furnished by the contact establishes another impulse,

resulting in the contracting of the muscles that grasp it. The next time the ball is suspended in front of the child, the same reflexes are produced, but in consequence of the previous practice, it is not likely to be so long before the hand comes into contact with the ball, and grasps it. The more frequently the hand is thus brought into contact with the ball, the more effective becomes the hand reflex and the less efficient or emphatic become the other reflexes. Finally the other reflexes almost disappear, and the effective reflex is the one that survives. This survival of the effective reflex is called functional selection.

Sensations Established.— Whenever the baby succeeds in grasping the ball, an impulse is established in the touch corpuscles of the hand, which is transmitted through some combination of cells in the touch center, and accompanies the sensation of touch. Whenever the muscles contract that bring the hand into contact with the ball, an impulse is started in the muscles themselves that is transmitted to the muscular sensation center in the brain, and accompanies the muscular sensation. Whenever he grasps the ball, he is likely to see his hand grasping it. An impulse is established in the eye which is transmitted to the sight center in the brain, and accompanies the sensation of sight.

Perception of the Action.—These several sensations experienced at the same time, perhaps with others, combine and modify each other, and accompany the perception of the action of grasping the ball. A perception center for this act is thus organized, and an impulse can be transmitted through it with little resistance. It ultimately becomes so well organized that a weak centrally initiated impulse may be transmitted through it, and when that is the case, the child can see himself grasping

the ball before the movement is actually made. When this point has been reached it is no longer a reflex, but a conscious voluntary act.

The Motive.—The difference between the reflex and the conscious voluntary act is that a mental process precedes the conscious voluntary, while no mental process precedes the reflex. This antecedent mental process is called the motive, and is always an idea, not a feeling. Any idea that is clearly entertained tends to work itself out into action, and may constitute a motive. The statement of this fact is called the law of Dynamogenesis.

Idea of One's Own Act.—The first motive is the idea of the act itself, or the idea of our own movement in performing the action. We must think just how we are expecting to do the act. The first time we perform any action, it is done as the result of an accident or blunder, without any clear idea of how it should be performed. The law of functional selection applies. When we learn to skate, or knit, or whet a razor our attempts are awkward and far from skillful. We may have watched some one else perform these actions, but when we undertake to do the same things, we find that we are able to perform them far from skillfully.

Not a Complete Idea.—The explanation of this fact seems to be as follows: When we watch some one else perform the act, we obtain a visual sensation of how it should be performed; but into the percept of an action enters also the touch, and muscular sensations, with others. It is impossible for us to obtain these sensations visually, by watching some one else, hence it is impossible to get a clear, motivating idea from seeing some one else perform it. We must get our motivating, effective, idea by a series of trials and gradual approaches toward the correct idea. This is sometimes called the method of

trial and error, although a very expressive designation for it is blundering.

Idea of Result.—We are never very skillful so long as the motivating idea is the idea of our own action. But as we become skillful, we can cease to hold before our minds the idea of our own action, and hold only the result of the action. A baseball batter, when he has become skillful, does not have in mind an idea of just how he shall stand nor how he shall hold his bat, nor just how he shall swing it. He merely sees in his mind the ball sailing over the back field fence, or cutting the grass between shortstop and second base, and then the ball goes exactly to that place. Or if he is an ear-minded individual, he holds clearly in mind the sound of the bat as it strikes the ball, and then it sounds in exactly that way. Or he may be a touch minded individual, when he has a clear idea of how the bat will feel when it collides with the ball. If, however, the idea is not clearly held in mind, the result will not occur.

Another Motive.—But the motive is capable of still further development. Even the idea of result may disappear, and the action follow immediately upon the receipt of the sensation without any previous contemplation of the idea of result. When a door begins to slam towards us, we throw up our hand to ward off the blow. There is no antecedent idea of our action, and no idea of the result to come from it. There is not the least intimation of the mental process that might be interpreted by saying "Now I must throw up my hand in this way in order to avoid being struck in the face." Nothing corresponding to this process appears.

Sensation as Motive.—But the appearance of the approaching door starts the impulse that terminates in the action. The motive here is merely the sensation. The

sight center and the corresponding motor center have been connected by so many experiences, and the pathway between the two has been traversed so many times, that the resistance is practically nothing, and the impulse flows directly into the motor center.

Secondary Reflex.—This kind of an action is sometimes called a secondary reflex, the qualifying word indicating that it has been derived from a conscious voluntary act. In fact, one school of psychologists insist that every reflex is of this nature. They have all been derived originally from conscious voluntary acts, and have become reflex as the result of habit.

Unconscious Voluntary.—A much more satisfactory interpretation of these actions is found in the description of them as unconscious voluntary actions. The nervous impulse traverses the same centers that it traversed, or would traverse, when the motive was the idea of our own act; but in consequence of repetition and habit, the brain center offers so little resistance that there is no feeling and no radiation with its concomitant consciousness. Such an action is sometimes called a sensori-motor act, the action following immediately upon the sensation. Sometimes these actions are described as involving only the "lower centers," meaning by that that the accompanying impulses do not pass through the cerebral, cortical, centers, but only through combinations of cells in the cerebellum or the spinal cord. There is no evidence of the truth of this supposition except the absence of consciousness, and we have a much more satisfactory explanation of that than the theory of lower centers offers.

Instinctive Action.—Instinctive action is the kind that is illustrated by the activity of a bird in building its nest, or a digger wasp provisioning its cell with caterpillars, or a mud dauber engaged in the same occupation.

Nature of Instinct.—We can best make clear the meaning of instinct by considering the nature of the impulse that accompanies it, and the brain center that is traversed. An instinctive brain center may be defined as a combination of cells in the cortex that is organized as the result of an inherited tendency to grow, and not as the result of experience. An habitual center is one that is organized as the result of experience. If we could imagine a person reaching maturity without any experience, we should find in his brain the instinctive centers organized, but not a single habitual center.

Definition of Instinct.—The instinct is the entire concomitant of the transmission of an impulse through an instinctive center. This implies that an instinct includes idea, or intellectual process, feeling, expression, or action. Sometimes one of these elements of the instinct is more conspicuous than the other, and then they may be called instinctive idea, or an instinctive feeling, or an instinctive action. But neither designation is sufficient to include the whole instinct.

Difference Between Instinct and Habit.—Instinct or instinctive action differs from habitual action in the fact that the instinctive action is performed without previous experience, that it is performed more skillfully the first time, and that it demands only spontaneous attention. In habit, the brain center is organized as the result of experience, it is not performed skillfully the first time, and it demands voluntary, effortful attention in the process of learning.

Between Instinct and Reflex.—The instinct or instinctive action differs from a reflex in the fact that the instinctive center is found in the cortex, that the instinctive action is complex, that it is accompanied by feeling, and by a motivating idea. The reflex center is in the cere-

bellum, or medulla, or spinal cord; it is a simple movement, it is not accompanied by any feeling and is not preceded by any motivating idea.

A Conscious Voluntary.—Shall we say that the instinctive action is a conscious voluntary action, or closely related to it? The difficulties in the way of adopting this explanation arise principally from the fact that the best examples of instinctive action are found in insects and other animals in which we are not inclined to recognize consciously intelligent behavior of any kind; and in man, the instinctive actions are poorly represented, and are obscured by others. But making due allowance for this fact, there appears to be no good reason for refusing to call instinctive actions, conscious voluntary. This implies that the instinctive action is preceded by a motive which is an idea, and nearly certainly an idea of the end, immediate or remote, to be attained by the action.

Indicates Intelligence.—A second question is whether or not a thoroughly fixed instinct is indicative of intelligence or the lack of it. It is generally assumed that an animal that possesses thoroughly fixed instincts is thereby demonstrated to be devoid of intelligence. But in the case of the human being, the actions that are best performed are those that most nearly approximate the condition of an instinctive action. In fact we sometimes speak of an unconscious voluntary action as instinctive, and assert that we performed it instinctively, without thinking about it.

Instinctive Ideas.—Another bit of testimony is that the ideas that are most nearly instinctive ideas, conforming to the definition of an instinct in every respect, are those that have sometimes been called intuitive ideas. It would be perfectly appropriate to call them instinctive

ideas, and the possession of them would never be suggested as indicating a lack of intelligence, but the absence of them would. Hence it seems to be a necessary conclusion that the possession of well organized instincts is an indication of intelligence of a considerable degree of complexity.

Origin of Instinctive Actions.—A third question concerns the method of origin of instinctive actions. One group of philosophers affirm that they originate as the result of habit in the ancestors, which brought about a modification of the nervous system, which was transmitted to the descendants, so that the instinctive center was organized in the descendants as the result of heredity, not as the result of individual experience. Instinct is thus described as inherited habit.

Variation and Natural Selection.—The other theory asserts that the organization of the instinctive center was accomplished as the result of variation, modifying the organization in advantageous ways, and that the experience of our ancestors had no share whatever in the organization. The principle is that acquired characters cannot be inherited. The latter explanation is adopted by the larger number of psychologists, although it cannot be said to be positively demonstrated.

SIDELIGHTS

There are no muscular movements in the internal direction of a train of thought.—*Saleeby, Psychology, p. 56.*

The expression reflex act is generally synonymous with an unconscious voluntary act.—*Morat, Physiology of the Nervous System, p. 508.*

As originally employed by Marshall Hall, and since then by common consent, reflex action involves a differentiated nervous system.—*Lloyd Morgan, Animal Behavior, p. 32.*

There is the remarkable difference that intelligent actions are centrally stimulated, while reflex actions are peripherally stimulated. —*Baldwin, Methods and Processes, p. 73.*

The mere idea of an act starts a chain of nervous processes that finally make the action real.—*Stratton, Experimental Psychology, p. 206.*

To make any movement voluntarily, the attention must be fixed upon some kind of an idea that represents that movement.—*Baldwin, Methods and Processes, p. 86.*

The idea of the movement has become, as psychologists so often tell us, itself a tendency to perform that movement; yea, the very beginning of that movement.—*Baldwin, Methods and Processes, p. 300.*

No act whatever can be performed by consciousness, by willing movements which have never been performed before.—*Baldwin, Development and Evolution, p. 86.*

Professor Royce says that we can directly will an act only when we have done that act before.—*Marshall, Instinct and Reason, p. 457.*

The sensory stimulus must express itself in some form of action before the perception can be set up.—*Colvin and Bagley, Human Behavior, p. 192.*

DEFINITIONS

Reflex Action.—The direct response of protoplasm to a stimulus. It is preceded and accompanied by no mental process.

Automatic Action.—A rhythmical, regular reflex action. No mental process precedes it.

Conscious Voluntary Action.—One that is preceded by an idea.

Unconscious Voluntary Action.—An action whose motivating idea is not attended by consciousness.

Motive.—The idea which precedes the conscious voluntary action.

Functional Selection.—The process by which an appropriate and useful reflex is preserved out of a series of reflexes, most of which are useless and inappropriate.

Instinctive Center.—A combination of brain cells organized into a center as the result of a tendency to grow, not as the result of experience.

Instinctive Idea.—An idea which is the concomitant of the transmission of an impulse through an instinctive center.

Instinctive Feeling.—A feeling which is the concomitant of the resistance encountered by an impulse in passing through an instinctive center.

Instinctive Action.—An action whose motive is an instinctive idea.

Instinct.—The entire instinctive psychon. The entire concomitant of an impulse passing through an instinctive center. It includes instinctive idea, feeling and action.

Habitual Center.—A combination of brain cells organized as the result of experience.

CHAPTER XXV

The Psychology of Early Infancy

Importance of Child Psychology.—The most important part of psychology for the teacher is that which deals with the mental processes of children. That these processes manifest differences from the mental processes of an adult will require no demonstration. The study of the mental processes of an adult is a necessary preliminary to any satisfactory understanding of the mental processes of children, but to omit a specific study of child psychology is like building a foundation without rearing the superstructure that it is designed to support.

Mental Conditions at Birth.—Let us now inquire what mental processes are in progress at birth, and what are the mental furnishings of the newly born infant. We shall find that certain reflexes are the only processes that are established at birth, and that these are such as are necessary for the immediate continuation of the life of the child. The reflexes that move the lips and the organs of the mouth are present, and these are necessary to enable the child to take its first nourishment. The reflexes that move the respiratory muscles are already well established, for without these movements the child would be unable to survive the first five minutes of an independent existence. The crying reflex is already established, and is immediately available. This likewise is essential to the child, for it is a demand upon the parent for assistance without which the life of the child is impossible. Perhaps we may associate this fact that the

demand of the child for assistance is made by an audible signal with the other facts that an audible signal is perceptible in darkness, and that there is no provision for closing up the ears as there is for closing the eyes.

The Grasping Reflex.—The reflex of grasping with the hands is also well established, and we find that the child in the first half hour of his independent life is able to grasp a stick or finger, and by means of that grasping reflex to support the weight of his body for a period varying from two seconds to a minute and a half. This reflex persists for several days or weeks, but finally diminishes. It points back to the time when the ancestors of the human race lived in trees. Such a reflex was without any doubt, of serious importance in the preservation of the child's life in the arboreal existence of primitive man, although it is no longer of essential value. It is a vestigial reflex, and is historical, rather than of immediate utility.

Importance of Early Reflexes.—All of these reflexes and many more are present at birth and are of essential importance for the preservation of the child's life in the first few minutes or few hours of his independent existence. They have been established by variation, fixed by natural selection and transmitted by heredity. Like all other reflexes, they involve no mental activity. It is characteristic of a reflex that it is not preceded by any mental process, and has no motive, in the psychological sense of the term, and cannot be considered as a manifestation of any element of the psychon.

Sense Activities.—We must look for the beginnings of mental life in the activity of the senses. The senses are at birth inactive. The child is born deaf and blind. He cannot taste nor smell. It is questionable whether the sense of touch or the sense of temperature is capable

of functioning. All of these senses must acquire their proper activity after birth. Let us study the development of the sense of hearing which may serve as a type of other senses.

Functioning of the Ear.—At birth, the ear is not ready to function. The external auditory meatus is closed and its edges are in contact with each other. Before the ear can function, it must open and permit the air to come into contact with the tympanic membrane. The middle ear is filled with liquid which must be drained away through the eustachian tube before it can become functional. When these changes have been accomplished, the ear is ready to function, but the child cannot yet hear. The vibration of the air strikes the tympanic membrane, but until the nervous impulse is established in the terminal filaments of the auditory nerve there is no possibility of hearing. We have no means of judging how many repetitions are necessary before the vibrations start a nervous impulse.

Organization of an Auditory Center.—After a nervous impulse has been established in the terminal filaments of the auditory nerve it must be transmitted to the hearing center in the brain before there can be any sensation of hearing. It may be that the very first impulse which is established in the terminal filaments is transmitted to the brain center and goes through a combination of brain cells, but from what we know of the transmission of a nervous impulse in a nerve and the improvement by practice of the rate of transmission through a nervous arc, it would seem more reasonable to suppose that the first impulse which is started gets only a little way in the nerve. The second impulse would travel the same path and would proceed farther along the auditory nerve than did the first one. The third and

succeeding ones would travel along the course of the first impulse, encountering less resistance than the preceding one, until finally a nervous impulse would succeed in getting into the brain center.

Establishment of Feeling.—But we know that in the brain center a greater resistance is encountered than in the nerve itself. Hence we should expect it to take a longer time to establish a pathway through the brain center than it did to establish one through the nerve. The first impulses that enter the brain center for hearing would, in all probability, be lost completely and fail to make a complete circuit. Hence its concomitant would be all feeling, and not an intellectual process, sensation. This is the interpretation that, in the light of present day knowledge we may put on Mr. Spencer's statement, that all intellectual processes grow out of feeling.

Initiation of the Auditory Sensation.—Finally there comes a time when the nervous impulse succeeds in overcoming the resistance, and goes through the nervous arc in the hearing center. A center for hearing is thus organized and the sensation of hearing is established. This process of organizing the brain center, overcoming the initial resistance, establishing the nervous impulse and modifying the nervous tissue until it will permit a nervous impulse to pass through, demands some time. Hearing may be established in the first two days of life, but it is more likely to be three or five days. A child may be deaf for three or four weeks after birth and still ultimately become able to hear, although if it cannot hear at the end of the fourth week of life the probability is strong that it will never hear.

Functioning of Other Senses.—The process which we have illustrated by means of the sense of hearing is the same process that is manifested in the original function-

ing of every other sense. It may be that the sense of touch, the most fundamental of all of the senses, is organized at birth, but the reflexes that are shown do not prove that it is. It is probable that the brain center for touch is not more easily permeable for the impulse that is established in the end organs for touch than is the center for hearing. Some of the senses are probably much slower than is the sense of hearing in developing. It is doubtful if the color sense becomes established before the child is seven months old, and perhaps it is much later than that. The sense of equilibrium is likewise slow in developing. But whether promptly or slowly we must recognize that all the senses ultimately become functional, and most of them in the first few days or the first few weeks of life. It remains for us to inquire what mental processes are involved in their activity.

Concomitant of Feeling.—We shall assume that the psychological concomitant of the resistance that a nervous impulse encounters in passing through a nervous arc is feeling. The first mental process that is experienced is feeling, coming even before the intellectual process of sensation, which is the concomitant of the transmission of a nervous impulse through a nervous arc. The resistance that is to be overcome in a brain center in process of organization is relatively great. It can be shown that the principal difference between a feeling that has a painful tone and one that has a pleasurable tone is one that is associated with a greater or less degree of resistance encountered by the concomitant impulses. The painful tone is usually, not always, associated with great resistance and the pleasurable tone with less resistance. Since the resistance that is encountered in the transmission of the first impulses through the nervous arc is a great one, we may say with a good

deal of probability that the first feelings are painful in their character. We reach this conclusion in a theoretical way, thus corroborating the observations of many people who have believed that they recognized in the first cries of a child an expression of pain.

The Expression of Pain.—The cry is an expression that later, we know, is associated with a feeling having a painful tone, and not with a pleasurable feeling. The cry much precedes the laugh, which we later learn to recognize as an expression of pleasure. Many observers refuse to recognize in the cry an expression of pain, but certainly it is not an expression of pleasure. In fact, all that we can say, if we refuse to recognize in the cry an expression of pain, and that the first feelings are painful, is that the cry is a reflex and not an expression of feeling in any degree. It is very probable that the first cry of a child is a reflex, and not an expression of feeling, and is no evidence that the first feelings are painful. But it is also probable that the first feelings are painful, and that the reflex cry comes to be adopted as an expression of a painful feeling because it is well established when the first painful feelings are experienced.

Consciousness.—There is one way of looking at the matter, in which we may say that the first mental process is not a painful feeling. We need to ask ourselves whether the child manifests any consciousness in connection with the process which we have described as a painful feeling. We have little to guide us except our theoretical considerations again. We may think of consciousness as the concomitant of the radiation of the nervous impulse out of the brain center into the fringing cells, which radiation is occasioned by the resistance which the nervous impulse encounters. Radiation depends upon resistance, and in the first nervous impulses

of the little child, when the brain centers are in process of organization, there is much resistance encountered. Hence we should expect that there would be much radiation and its concomitant consciousness. But at the same time that resistance is encountered in passing through the brain center, there is also great resistence encountered in trying to pass into the fringing cells. Hence it is very doubtful if in the first nervous impulses there is any radiation and any concomitant consciousness.

Feeling Without Consciousness.—Shall we say that without consciousness there can be no feeling, or shall we say that pain may be experienced whether there is consciousness or not? If we adopt the opinion that there can be no mental process without consciousness, or awareness, of the mental process, then we shall be compelled to say that in the first mental experiences of a child, the first feelings, the concomitants of the first nervous impulses, there is no pain, and no other mental process. But this use of the word consciousness lands us into very great difficulties, and it seems much better to say that there may be many mental processes without accompanying consciousness, or awareness of the process. Then we may say that even though consciousness has not yet manifested itself, the feeling of a painful tone exists.

Consciousness Established.—Feeling, then, appears in the psychon before consciousness. When repeated attempts to pass through a brain center, and as frequently repeated attempts to radiate out into the fringing cells have so modified the brain cells that the nervous impulse can escape, then we have the physiological conditions that accompany consciousness, and this second element of the psychon has become established. The first consciousness is very vague and indefinite, and this

fact in itself modifies the expressions that tell of the presence of the other elements, and renders the determination of the first appearance of consciousness in the psychon impossible. At the very best, the first appearance of consciousness—the word is here used in its limited meaning of awareness—must bear about the same relation to the fully developed consciousness that the acorn bears to the tree that springs from it.

Perception.—From a single sense a child gets a single sensation. This is scarcely complex enough to be called a perception, although the difference is not very great. From every sense he may receive a sensation when all of them become active. There comes a time, after many sensations have been received from different senses, that the nervous impulse established in one end organ combines with the impulses established in other sense organs. We have then, two or more nervous impulses established at the same time which run together, and we have two or more sensations experienced at the same time that modify each other. This is the condition of perception.

Perception of Resemblance.—The first experience that leads to perception is not in itself a perception. Perception involves the recognition of relation and since it is possible to use the word resemblance in a meaning broad enough to cover all forms of relation, we may say that perception involves the recognition of resemblance. This recognition of resemblance implies that some brain cells are traversed by a nervous impulse that have been traversed before. We shall never have a perception unless some of the cells involved have been traversed by an impulse on a previous occasion. This retraversing of the same cells constitutes an essential part of the physiological process which accompanies perception.

Memory.—We have now seen how it is possible to conceive the establishment of all the elements of the psychon, including the elements of feeling, consciousness, and the intellectual process, which by increasing complexity becomes judgment, reasoning, etc. Memory is not a new or totally different process. It is established in consequence of the modification of the nervous arc by the transmission of a nervous impulse through it. The process of memory may be considered as having its psychological concomitant in the transmission of the nervous impulse through the same brain centers that it went through before, and the spreading out into the same fringing cells. As repeated experiences which are accompanied by the transmission through a nervous arc become more numerous, and the nervous impulse spreads out into the fringing cells, the arc becomes modified in such a manner that it is very easily traversed, even by a feeble impulse, which may be a centrally initiated one. When such a centrally initiated impulse is able to traverse such an arc and to spread out into the same fringing cells, we have the physiological concomitant of an act of memory in its two phases, mental reproduction and mental recognition. There is no new element introduced. The nervous impulse goes through the brain center, the concomitant of the intellectual process; it encounters resistance, the concomitant of feeling; it radiates out into the fringing cells, the concomitant of consciousness, or mental recognition. Thus we have established all the psychonic elements.

Personality.—It is necessary for us to consider the establishment of one other process, the development of the consciousness of self, or personality. Here, too, we are compelled to invent some kind of an hypothesis by means of which we can picture this process to ourselves

in understandable terms, which seems to limit us to the consideration of a possible physiological concomitant.

When a Child Becomes Conscious of Self.—The child may be conscious of an experience without being conscious of himself as experiencing. The consciousness of self comes much later than does consciousness, meaning awareness. The first recollections of a person are usually those of something that has been experienced somewhere between the age of one and three years. When such an event happens that is thus remembered, we may be satisfied that the consciousness of self, or personality, has become fully established. The time at which a child discovers that he has hands, or that his hands belong to him, is an important epoch in his life. It is a phenomenon that is seldom overlooked by a mother, or other person who has intimate knowledge of a baby. The probability is that the consciousness of self, or personality, has become established some time before the first remembered experience has occurred, or even before the child has found his hands.

Personal Identity.—After a child has arrived at a certain age in his experiences, which point is reached before he has attained the age of two years, or a year and a half, perhaps by the age of nine months, his brain centers have been traversed by so many impulses, and so many different brain cells have been exercised that no subsequent experience is likely to involve a wholly new set of brain cells. The feeling of familiarity, or resemblance, is to be found in all subsequent experience, however diverse. Every experience has an element of sameness which is associated with the employment of the same brain cells. It is this element of sameness in every experience which, when abstracted, constitutes the feeling of personal identity.

Physiological Concomitant of Personal Identity.—We may picture the matter to ourselves in this way: We have in our brains perhaps seven hundred million brain cells. It is probable that no large proportion of them is ever traversed by an impulse. Let us suppose that one hundred millions have at some time been traversed. Let us represent this group of a hundred million brain cells by A. Let us represent another group of a hundred million cells by B, and so on. All of our previous experiences have been confined within the limits of the hundred million cells designated by A. Let us suppose that we could have a totally unrelated experience, open up a new series of sense organs, have nervous impulses carried to a different set of brain centers which would involve none of the cells in A, but which should be accompanied by impulses through groups of cells designated by B, C, etc. Then we should cease to be the persons that we now are, and we should manifest a new and totally different personality. Such a conception will enable us to explain the phenomenon of double personality, such as is manifested in the cases of Ansel Bourne, Mary Reynolds and Felida X. (See James' Psychology, Volume I.) Whenever there comes a time that it is impossible to have an unrelated experience, we may say that a personality has been born. Until an unrelated experience is impossible, personality, or the consciousness of self is still undeveloped.

Imitation.—It is in this period of early infancy that the process of imitation becomes established. Somewhere between the ages of three and nine months the child becomes able to imitate the actions of another person, and this imitative process is a necessary preliminary to the beginnings of conscious voluntary movement.

How Imitation Is Established.—The first movements

of a child that follow upon the activity of the sense organs, such as sight and hearing, scarcely differ from reflexes. When a stimulus is furnished through the eye by such an occurrence as the waving of a parent's hand, an impulse is established in the end organ, that being peripherally initiated is strong, and is capable of going through a sight center. In this center it encounters resistance, which leads to the attempt to spread out into other cells and centers. It will overflow into those centers that are most easy to access, and these are likely to be the motor centers, because the motor centers are among the first that are organized, the most frequently used, very often associated with the sense centers by a common nervous impulse, and lie directly in the middle of the brain surface. Hence it is that any strong impulse, such as a peripherally initiated impulse, is very likely to flow over into the motor centers, and a motor response follows.

Uncoördinated Movements.—But the first motor response is not likely to be a copy of the action that furnishes a stimulus. The child may respond by a movement of the head and the legs and the whole body, as well as by a movement of the hand. But the movement of the hand is one of the movements that is likely to follow. The movement of the hand establishes two other sensations, one the muscular sensation that is experienced as the result of the contraction of the hand waving muscles, and the other is the sight sensation corresponding to the movement of the child's own hand. The combination of the two impulses and their corresponding sensations, the muscular sensations and the sight sensations of the waving of the child's own hand, establishes the perception of the child's hand moving. Various repetitions of this movement result in the better

organization of the center that corresponds to the movement of the child's own hand.

Functional Selection.—Then there comes a time when the waving of the parent's hand is followed by the moving of the child's hand in a similar manner without the movements of the other parts of the body that constituted a part of the first response. The movement of the child's hand has survived, and the movement of the other parts of the body have not. This process of the survival of the appropriate movement is called the law of functional selection.

Concomitant of Imitation.—The waving of the child's hand in response to the waving of the parent's hand follows as a result of the recognition of the resemblance between the hand movement of the parent and the hand movement of the child. The movement of the head or of the leg does not follow, and the movement of the hand does, because the moving of the hand is perceived to be similar to the moving of the parent's hand. The perception of resemblance is the concomitant of the transmission of the nervous impulse through the same cells that have been traversed before. In the perception of the waving of the parent's hand a nervous impulse has traversed a certain combination of brain cells, some of which are the same cells that are traversed when the child's hand is seen to wave. The resemblance is perceived because the things do resemble each other. When the impulse enters upon the cells of the hand-waving center, it spreads out and traverses the cells and centers that have been previously organized into connection with it as the result of previous experience, and some of these cells and centers are those in the motor area. Hence it is that the child's hand waves, finally, when the stimulus is furnished by the waving of the parent's hand.

Perception of Resemblance in Imitation.—This is the process that we call imitation, and it is a process that involves the perception of resemblance between the imitation and the thing imitated. It is the process by which the little child comes to know the meaning of the things that he sees, and it is his method of interpreting things to himself. It is an intellectual process, simple and crude, and is the first step in learning the meaning of things.

A Conscious Voluntary Act.—A conscious voluntary act grows out of an imitative act. As a result of repeated imitative wavings of the hand, the brain centers involved in the process become so organized that a weak nervous impulse, such as a centrally initiated impulse is, may pass through it. Such a centrally initiated impulse passing through the sight center and the muscular sensation center that have previously been traversed when the child's hand has waved, is the concomitant of the idea of the waving of the hand. When such an impulse traverses the sight hand-waving-center and the muscular-sensation hand-waving center, the child can see and feel his hand waving before the motion occurs. He has an idea of the movement of his own hand, and this idea, if it is strong enough, and not inhibited by some other circumstance, will result in movement. The idea of the movement is the antecedent mental process and constitutes the psychological antecedent, or the motive, to the action. Hence we see that conscious voluntary action originates in and grows out of a reflex in passing through a process of imitation. If it were not for the antecedent imitative process, the conscious voluntary act would not become established.

Hypothetical Conclusion.—The above conclusions have been reached in the only way that it seems possible

to reach any conclusion concerning the first appearances of mental life in the child; that is by bold hypothesis and carefully considered theory. Such hypothesis has been based upon the very limited number of facts that we do know, and has been reached by careful processes of reasoning with due allowance for possible errors. We may trust it to the extent that we have avoided errors in reasoning, and have made allowance for undetermined factors in the problem. An experimental verification by direct observation of physiological process will, in all probability, be forever impossible. The hypothesis may be considered valid so long as it explains the facts of observation, and helpful so long as it enables us to picture the processes in understandable terms. When it fails to do this, we must discard it and substitute one more in harmony with the facts as then known.

SIDELIGHTS

Infants scream from pain directly after birth.—*Darwin, Expression of the Emotions, p. 352.*

Accommodation by muscular imitation does not arise in most children until about the seventh month, so utterly organic is the child before this, and so great is the impetus of its inherited tendencies and instincts.—*Baldwin, Methods and Processes, p. 336.*

The original end of volition therefore is simply the image or picture which starts the imitative reaction.—*Baldwin, Methods and Processes, p. 472.*

Imitation differs from intelligence in being a general form of coördinated adaptation, while intelligence involves a series of special forms.—*Baldwin, Development and Evolution, p. 66.*

In the unity which embraces and holds together the different sensations and ideas, and makes their interaction possible, is the germ of the conception of the ego, or self.—*Höffding, Psychology, p. 136.*

If the infant's first cry is called forth by urgent want of air, consequent upon the interrupted placental circulation, life begins with anguish.—*Höffding, Psychology, p. 226.*

The cerebrum of the infant seems, in fact, in large part to consist of nervous matter, not innately organized but constituting an immense mass of plastic material which gradually becomes organized under the touch of experience.—*McDougall, Body and Mind, p. 275.*

The sense of our personal identity is exactly like any one of our other perceptions of sameness among phenomena.—*James, Volume I, p. 334.*

From our preceding remarks it seems that the nature of mind is its behavior generalized.—*Baldwin, Development and Evolution, p. 274.*

DEFINITIONS

Imitation.—The process by which an action is made to conform more or less closely to the action of another individual. The process by which an action is made to conform more or less closely to an idea which is obtained from another action or another object.

Personal Identity.—The idea that we are ourselves, and not something else.

Personality.—The sum of all the characters which constitute the individual.

Early Infancy.—The period of a child's life from birth to about 18 months of age.

CHAPTER XXVI

The Psychology of Later Infancy

Limits of the Period.—The period of later infancy begins at about the age of eighteen months or two years. It is characterized by certain physiological and psychological changes which do not all occur at the same time, nor does any one of them manifest itself suddenly. Consequently, it is very difficult to establish a date at which the transition from earlier to later infancy takes place. If we contrast a child of three years with a child of six months, we shall discover the differences that separate the two periods.

Distinguishing Characteristics.—The child of three years has teeth, the child of six months has no teeth. Associated with this difference we recognize also a difference in the character of the food. The child of three years eats solid food, while the child of six months is nourished by milk or other liquid food. The child of three years can talk, while the child of six months cannot talk. The child of three years can walk while the child of six months cannot walk. The child of three years manifests decided symptoms of fear of many different things, while the child of six months is incapable of manifesting fear. Some of these changes begin to occur by the time the child is nine months old, and others are not completed until the child is almost three years old. It is impossible to fix upon a particular definite age for the time of transition, and it is equally impossible to

specify one particular process or character which we may adopt as the distinguishing mark of the change.

No New Psychonic Elements.—In the period of earlier infancy every element of the psychon has been established; but there are changes occurring in the mental life of the child that appear only when the period of later infancy has been entered upon.

Infantile Independence.—Many of the changes the child undergoes in passing from earlier to later infancy may be described as originating in the development of an instinct of limited independence. We have no word to express exactly the degree of independence here indicated, but we may describe it as infantile independence. We may call it an instinct, although it might perhaps as properly be described as the development of a group of instincts. Associated with this instinct of infantile independence is the coming of the teeth and the correlative change in food. When the child begins to eat solid food he is not so completely dependent upon his mother as he was before.

Walking Instinctive.—Either as a separate instinct, or a manifestation of the instinct toward infantile independence, is the process of walking. At first glance, nothing seems more evident than that a child learns to walk; but it can be shown that walking arises as the result of the development of an instinct, and not as a matter of teaching, nor of muscular growth. It is probable that so far as muscular power is concerned, the child at birth has muscles strong enough to enable him to support his body and to walk. We may judge this from the strength of muscle manifested in the grasping reflex, and also from the analogy of the young of other animals. The young of animals that escape from their enemies by running away can walk as soon as they are born. The

lamb, colt, chick, calf, can walk at birth, and do not need to learn. In such animals the ability to walk at birth is decidedly advantageous to the preservation of the young, and the instinctive action of walking has its mechanism already organized. On the other hand, the young of animals that escape from their enemies by concealment rather than by flight, such as cats, tigers, mice, rats, muskrats, cannot walk at birth, but such ability is attained only after a considerable interval. It would appear, then, that walking is not something that comes to the child as the result of teaching nor as the result of the growth of muscular power in the legs. The suddenness with which, in many cases, the child begins to walk would seem to imply also that walking results as the development of an instinct, rather than as the result of teaching. The development of an instinct means an organization of nervous mechanism in the brain. Until this mechanism has been organized and the instinct developed, no amount of teaching can lead a child to walk.

Why Not Walk Early.—Nearly all children creep before they walk, and creeping is not supposed to be the result of teaching. It would appear that there is as much muscular exertion employed in creeping as in walking, but that the child is unable to walk in consequence of the failure of the sense of equilibrium to function. Besides this, the walking mechanism demands that there shall be a coordinating alternation of the muscles of the legs, and it is this coordinating mechanism that seems to be the last thing developed before the child begins to walk.

Climbing.—The child can climb before it can walk. It early manifests a disposition to climb upstairs, and climbs up in preference to down. There is little danger in climbing up, but the dangerous process is involved in

going down. It would seem that the climbing is the result of an instinct, which was no doubt of essential importance in the early history of the race. It is a vestigial reminiscence of the time when the human race was arboreal in habit. There is a rather well marked period of early truancy, about the age of three, which is indicated by the disposition of the child to get away from his mother or nurse out of the house or out of the yard and run away, often to the great distress of those who are responsible for his safety. We may consider this another manifestation of the instinct of infantile independence, and it is closely associated with the walking instinct.

Talking.—Talking is another process which indicates progress in the psychical nature of children. Nearly all children begin to talk somewhere between the time that they are nine months and three years old. It seems to make little difference, ultimately, in the talking ability whether a child begins to talk at one year old or three.

Talking Instinctive.—Talking seems to arise in consequence of the development of an instinct, and not as a result of teaching. If we may suppose two children reared on an island where they may never have heard a spoken word or a vocal sound except that which they themselves have made, they would still communicate with each other by language. They would invent a language of their own. Even in the midst of society, where children hear a language every day, in many instances children have invented their own languages instead of adopting that which is employed by the persons with whom they are associated. It is probable that the great variety of languages over the earth has originated in part from the exuberance and strength of this

talking instinct, leading to the invention of languages by children. The tendency of our modern complex civilization is to repress and stamp out any tendency to variation in language which may arise at present in this way; but the instances that have been observed, and which manifest themselves to a certain degree in every child in the development of speech, show how strong the instinct is. The particular language that is spoken depends upon teaching, or upon the language which they hear and which they learn by a process of imitation.

Left Handedness.—The development of the talking instinct is closely associated with the phenomenon of left-handedness, or the differentiation in the use of the two hands. About fourteen out of fifteen children are right-handed. The speech center is, in nearly all cases, in the left hemisphere of the brain, near the lower extremity of the fissure of Rolando, in close proximity to the center that moves the right hand and arm. No fact is better established in brain physiology than that when one portion of the brain has its ganglion cells developed, it influences the development of the ganglion cells in close proximity to it. Hence it comes about that the development of the functions of the right hand seems to exert an influence upon the development of the speech center. So, if the child is right-handed, and the speech center is on the left hemisphere of the brain, it will become earlier and better organized than if the child is left-handed. If a child is left-handed, and the speech center is on the left hemisphere of the brain, the development of the talking instinct must proceed without the assistance derived from the functional growth of the hand center in proximity to it. Hence it follows that in left-handed children, there is likely to be a defect in speech, a lisp, stammer, or inaccuracy in pronunciation

of words, or a delay in talking. A left-handed child may not begin to talk until he is three years old, while if the same child had been right-handed, he might have talked by the time he was two.

Left-Handedness and Speech Defects.— So very noticeable is this fact that some psychologists have asserted that every left-handed child has or had a defect in speech. Perhaps this statement is too extreme, and is not universally true; but so very many examples of it may be found that it affords strong evidence of the intimate connection between the organization of the speech center and the development of the talking instinct.

Beginning of Language.—It is necessary for us to understand what we mean by the beginning of speech in children. If we adopt as the indication of beginning speech, the use of the first words, then many children begin to speak about the age of eleven months, or even of nine. At the age of nine months the child is likely to have a vocabulary of about nine words or discriminating expressions, which is not far from the extent of the vocabulary of chickens, dogs, horses, and some other animals. But if we adopt the employment of sentence structure as the real indication of the development of speech, the child does not begin to talk until he is about twenty-three or twenty-four months old. After the child has reached the age of eleven months, the vocabulary rapidly increases. One series of studies has shown that at the age of twenty-eight and thirty months the vocabularies of two children contained 370 and 451 words respectively. Many children, in favorable circumstances, by the time that they arrive at the age of six years have a vocabulary of two thousand or three thousand words.

Fear.—We may recognize in later infancy, also the development of the instinctive feeling of fear. Fear is a

feeling of the utmost importance in the preservation of the individual. It is rather late in developing, and is advantageous to the individual only when the child has become able to leave the immediate care of his mother and take up an existence that is semi-independent. While the child is so completely dependent upon the care of the mother, the feeling of fear would be distinctly disadvantageous. The little child is afraid of nothing, but he begins to be afraid about the time of the coming of the first set of teeth. Thus we may consider the feeling of fear as a manifestation of the general instinct of infantile independence, or regard it as a separate instinct.

Fear Instinctive.—The instinctive character of the feeling of fear is often obscured by the fact that it frequently accompanies the recognition of previously entertained experiences, and a recollection of previously experienced consequences, thus seeming to originate in experience or to be inculcated by teaching. Children become afraid of the dark, instinctively, but the expression of the feeling and the feeling itself may be much modified by suggestion, imitation, teaching, and may be either increased or decreased by these circumstances. The same thing may be said of the fear of furred animals and large feathered creatures. Not every child will manifest it in such marked degree and so suddenly as some children certainly do. The feeling of fear is instinctive, but the fear of particular things does not manifest itself until the mental processes become sufficiently complex to adjust themselves to situations involving elements of danger to the individual.

Four Instincts of Later Infancy.—We thus discover that the essential differences between the psychical life of a child in the period of later infancy and that of earlier infancy depend upon the development of four instincts;

first, the instinct to talk; second, the instinct to walk; third, the instinct of fear; and fourth, the instinct to become independent to that degree that we have called infantile independence. While we thus regard these instincts as four, it is easily possible to multiply the number, and it is equally possible to reduce even these four to the one of infantile independence. The number of instincts depends upon the closeness of discrimination that we employ. Recognizing the presence of these instincts we can by means of them interpret the characteristics of infancy that distinguish it from other periods in the life of the child.

Children's Feelings.—The feelings of children are intense and vivid. The tissues of the body are largely composed of liquid, the protoplasmic activity is great, much nervous energy is generated, and the brain centers are poorly organized. Hence it is that as a result of the large amount of nervous energy encountering much resistance, much feeling is experienced. Children cry or laugh a large part of the time, and they do one about as easily as they do the other.

Physical Feelings.—The feelings in the period of infancy are largely those that relate to the physical functions. They are the feelings that accompany the sensations of hunger, thirst, temperature, touch, taste, respiration and muscular movement. There is in this period of infancy little or no such feelings as pity, sympathy, shame, modesty, affection, nor any other kind, except in a very rudimentary degree, than those that are called egoistic, or self-preserving. The infant is a non-social, egoistic, self-centered being whose only business is to live and he makes everything else contribute to that end. His feelings are such as induce him to perform actions that tend to preserve his life, or to secure the aid

of other persons in accomplishing the same result. A proper appreciation of this fact is a necessary condition for the understanding of the mental life of an infant, for it is out of this characteristic that spring those actions which are peculiarly infantile in their nature.

Children Non-Social.—The non-social character of children is best exemplified in their plays. The plays most characteristic of infants below the age of five or six years are individual plays. They do not demand the cooperation of another child of the same age. It is true that two children do sometimes play together. They will slide down the same cellar door, but one of them waits while the other slides down. Sometimes what may seem to be cooperative plays are engaged in at the suggestion of older persons, and such suggested cooperation conceals the real nature of the play. A very common playmate for a little child is the parent, who may toss the child up until his heels kick the ceiling, to the great satisfaction of the child. Here it may seem that there is a real cooperation, and that the play of the child is not a solitary play. But the parent is merely a means of furnishing to the child a new sensation, and a machine that would perform the same operation would be enjoyed as much by the child. The game is as truly noncooperative as if it were performed in some other way than by the activity of the parent.

Plays of Children.—The plays of children in the period of infancy are mostly sense plays and imitative plays. In the imitative plays we have another occasion for the misinterpretation of the non-social nature of children. Occasionally the plays imitate accurately a cooperative process, and the result closely simulates a cooperative play. A case of this kind is one in which two little girls played mother and baby. One of the

children assumed the part of the mother, and the other that of the baby. But the cooperative nature of the process that is imitated must not deceive us concerning the essentially non-social nature of the child.

Sense Plays.—Sense plays constitute the other great group into which the plays of infants are divided. Play is any activity that is undertaken for the sake of the activity itself, and the activity of the senses furnishes a motive for engaging in plays that call the senses into activity. Sense plays are altogether solitary and individualistic and are characteristic of infancy. Not only the activity of the sense of taste and sight and touch furnish pleasure, but especially is the muscular sense the source of many plays. The child is very much disposed to jump up and down in one place, thus showing that the purpose of the activity is not locomotion, but the mere exercise of the muscles for the enjoyment derived from the muscular sensation. It is the muscular plays of children that furnish Herbert Spencer with the basis for his theory of play, just as it is the imitative plays that furnish Groos with the foundation for his theory. Spencer believes that play originates in the necessity for working off surplus energy, while Groos believes that play furnishes practice for activities in which the child will subsequently engage.

Non-Moral Nature of Children.—When we have recognized that the prevailing character of childhood is determined by the egoistic, or self-preserving feelings, we are ready easily to understand that the moral nature is embryonic or feeble. If we examine the attitude of the little child toward truth, honesty, obedience and courage, we shall find that these virtues, essential to community life, are rather conspicuous by their absence in the egoistic life of the child. They are virtues that arise

only as a result of the development of social feelings, and are not to be expected where social instincts are wanting.

Children's Lies—The little child will lie. He will report as seen or done or heard things that are not done or seen or heard. The child who is not a born liar is precocious and something is the matter with him. Lying sometimes arises from hallucination or illusion. The large amount of nervous energy that is generated renders a centrally initiated impulse almost as strong as a peripherally initiated impulse would be, and the child mistakes an idea for a percept.

Originate in Fear.—But nearly all of children's lies arise as the result of weakness. The child fears to be detected in a fault, and so, lacking in courage, he takes refuge in a lie. He is dominated by the egoistic feeling of fear rather than the social feeling of courage. A lie is to him what the Sunday school pupil who had got his catechism mixed described it "An abomination to the Lord, and an ever present help in time of trouble." Fear is a feeling necessary and appropriate to infancy, since it is a self-preserving feeling. Courage is a community preserving feeling, and the infant is not yet a social being. We say of a child that he is not old enough to know any better, and that lying is too harsh a term to apply to his deviations from the truth. This is a recognition of the fact that truthfulness is a matter of development. The child will become able to tell the truth as he grows and develops.

How Overcome Lying.—It is not so much teaching as it is physical growth and the proper ethical atmosphere that is the condition of moral growth. The child is likely to become able to tell the truth and develop courage by the time that he gets through the period of infancy, but we should not expect him to do so before.

Not punishment, but good feeding, good examples for imitation, and proper expectation, which furnishes the suggestion for telling the truth is the proper method to employ for inculcating the virtue of truthfulness.

Honesty.—All that has been said about truthfulness may be said with even greater positiveness about honesty or stealing. All children will appropriate the property of others to their own use, and we may call this stealing, although some will feel that is too harsh a word to apply if the child is still an infant, or only two or three years old. We recognize that regard for the rights of property is a matter of development and growth. Good feeding, correct physical growth, and the proper ethical atmosphere is the principal and only proper method of procedure in order to cause a child of good heredity to pass out of the condition in which dishonesty is to be expected into that of integrity. The heredity may be so bad that the instincts leading to honesty never develop.

Obedience.—Obedience is not a virtue of infancy. The infant does not know the meaning of obedience, but he must learn it. Obedience to natural laws comes as the result of painful experiences arising from their infringement, and the child needs to learn to obey the commands of authority in the only way that he can learn them, by painful consequences arising from their violation. Commands of authority are usually given to obviate too serious consequences arising from the infringements of nature's laws. Obedience and respect for law are virtues not wholly attained in the period of infancy.

How Children Reason.—The one common element in all forms of the intellectual process as in all forms of reasoning, is the perception of resemblance. Any form

of intellectual process which demands a perception of resemblance may be called a form of reasoning. The little child early comes to recognize resemblance, for the process is involved in any perception. He recognizes things, and recognition involves a reasoning process. The child rather early reasons by analogy. The three-year-old child who said "If this is below"—motioning with his hand—"this—"(another motion) "is be-up" reasoned by analogy. "What are you brooming it out for?" asked a little child, when he saw his father sweeping out a box. "What makes ice undo itself?" is a good example of reasoning by a child of three and a half. Reasoning by analogy comes very early in the period of infancy. It often leads to invalid conclusions, and unthinking persons say that the child does not reason. What people really mean when they say that a little child does not reason is that the child does not delay his conclusion and inhibit his reasoning until he can correct his premises. The child reasons too promptly and reaches his conclusion without taking into account modifying circumstances. The intellectual element of the psychon, which involves in germ all reasoning processes is established very nearly as soon as is any other element.

SIDELIGHTS

The child was supposed to learn to walk. The fact that a chick can walk when it comes out of the shell would have sufficed to prevent this error on the part of the empiricists if physiologists had earlier appreciated the importance of comparative physiology.—*Loeb, Physiology of the Brain, p. 242.*

It is noteworthy also that at this stage of the development of the sense of dependence, there is little or no ethical ingredient. The child is from the third to the fifth year, or longer, more intelligent than ethical.—*Baldwin, Social and Ethical Interpretations, p. 349.*

There is a period of relative selfishness in the child, extending from the third into the sixth year. It is an incident of his growth. —*Baldwin, Social and Ethical Interpretations, p. 301.*

The reflex (walking) seemed to come quite suddenly, for up to the middle of the eighth month I could not discover more than a single alternation.—*Baldwin, Methods and Processes, p. 82.*

DEFINITIONS

Later Infancy.—The period of a child's life from about the age of eighteen months to six years.

Infantile Independence.—That degree of independence which is attained by a little child in the period of later infancy.

Play.—Any kind of activity which is engaged in for the sake of the activity itself; not primarily for the result of the activity.

Sense Plays.—Any kind of activity that is undertaken for the purpose of furnishing an opportunity for the exercise of any of the senses.

Imitative Plays.—Any activity undertaken for the sake of reproducing the activities or ideas of others.

Fear.—A self-preserving, instinctive feeling, accompanying the perception of a situation that is dangerous, or strange, and whose expression is a shriek, running away, or rarely, a temporary paralysis.

CHAPTER XXVII

The Psychology of Childhood

Childhood.—The period of childhood succeeds the period of infancy. It is that part of the life of the individual which is included approximately between the years of seven and fourteen, plus or minus about a year, or a year and a half. Its limits are determined, not by years, but by certain physical changes which are accompanied by corresponding psychological differences. As in other changes in the life of a child, it is difficult to specify a particular time, or to indicate a particular process which may be adopted as the distinguishing mark that separates childhood from other periods. If we compare the child at two stages, each of which will be recognized as undoubtedly belonging to its appropriate age, we shall understand what the changes are that discriminate the period of infancy from the period of childhood. The child at the age of five years is undoubtedly an infant, while the child at the age of eleven, or even at the age of eight is as unquestionably a child. Let us see what changes have occurred between the ages of five and eleven, or what changes can be accurately recognized as taking place between the ages of six and eight.

Rapid Growth.—In the first place, there has been a period of rapid growth. In one of these years the child has grown more than he grew in the preceding year and more than he will grow in the following year. With some children this year of rapid growth is the one from six to seven, and in others it is the one from seven to

eight. But there is a rather well marked period of rapid growth about this age in every child.

Second Dentition.—In the second place, the child has shed his first set of teeth and the second set are coming in. The first set numbered twenty and the second set are thirty-two. It is not necessary to suppose that at the time of the transition the entire thirty-two teeth have been acquired, but practically the entire twenty of the first set have been replaced. The head has acquired almost its full size, and is now at the age of eight as large as it will ever be. The brain is practically as heavy as it will ever be, what additional weight it may subsequently acquire amounting to not more than an ounce or two. In this period of rapid growth the disease resisting power of children is decreased, and more children die than died in the years immediately preceding it. However, the infantile contagious diseases are not so prevalent, nor so likely to attack the child subsequently as they were to attack the infant of the preceding years. Croup is almost limited to the age of infancy.

New Instincts.—Corresponding to these physical changes new instincts are developed and new interests arise. The child experiences new psychical processes, and new activities are incited by them. We can best understand the psychical phenomena of childhood by observing the differences that distinguish the child from the infant.

Independence and Gregarious Instincts.—The infant is selfish, egoistic and dependent. His only business is to live. His plays are solitary, individual plays, almost exclusively sense plays and imitative plays. When the infant enters upon the period of childhood, there is rather an abrupt transition to a kind of play that demands the cooperation of another child. An adult per-

son is no longer a suitable playmate for him. There is a disposition to break away from the domination of the parent, and to associate with children of his own age. We have in the numerous variations of this disposition an indication of the great change from infancy to childhood which marks the birth and development of two great instincts. One instinct is that of independence, and the other, which may seem in some degree contradictory to the first, is the tendency to become cooperative, or gregarious.

Necessity for Their Development.—Out of these two great instincts, or instinctive tendencies, flow all the peculiar characteristics that distinguish the child from the infant. It is possible to explain all the actions peculiar to childhood by means of them. The activities and the instincts from which they spring are biologically brought about by variation, fixed by natural selection and transmitted by heredity. In the history of the race it will be found that the advantage lay with the individual who became independent and strong enough to care for himself, and to continue in a state of independence. Also, in the history of all animal races that adopted community life as a means of survival, there is a necessity for the development of the gregarious spirit with all of its accompanying unselfish feelings. These unselfish feelings constitute the incentives to altruistic actions that tend to preserve the comunity, and which we call moral.

Disobedience.—In the light of these two great principles, which are positively fundamental, let us try to understand some of the characteristics of childhood. One of the most noticeable tendencies of a child is a disposition to become disobedient and willful. It is true that in the period of infancy, the infant has often failed

to do things that he was told to do, and has done many things that he was directed not to do. In the case of the infant, the doing was for the purpose of obtaining something which he desired, but in childhood, the typical example of disobedience is a manifestation of pure willfulness. It arises out of a disposition to disobey, and is often accompanied by a positive protest or an expression of ill-will toward the person whose command is disobeyed. It is generically different from the case of infantile disobedience and is not always for the purpose of obtaining a forbidden gratification, but for the purpose of manifesting independence.

Two Species of Disobedience.—Not all cases of disobedience seen in children between the ages of seven and fourteen are to be considered generically as those of childhood. Infantile disobedience persists, just as the sense plays and imitative plays persist; but there is introduced into this period of childhood this new species of disobedience which is not found in infancy. We have to distinguish, then, in this period of childhood two species of disobedience, the infantile and the childish. A recognition of these two species will enable us to interpret the actions of children much more satisfactorily than we should otherwise be able to do, and to avoid many difficulties in the management of them.

Disregard for Parents.—We may observe in this period another characteristic which is related to the disposition to become independent. In this period, the boy especially comes to regard his parent as little acquainted with the facts of his own experience. He is likely to think that his parents, upon whom he has so implicitly relied in the preceding stage of infancy, really know little, quite decidedly less than he does himself about the particular problems to which he turns his attention.

He is very likely to believe what his companions and children of his own age tell him, and to act upon their advice rather than upon that of his parents. This is a characteristic of children, distressing to parents and teachers, and whose explanation it is so difficult for them to understand. We may regard it as an effort of child nature to make itself independent and self-reliant, and as something that is not to be regretted, but to be understood and taken into account. It is often better to let a child go his own way, even though it should prove to be not the better way as seen by adult eyes, rather than that this tendency to independence should be repressed.

Courage.—In the period of infancy, the self-preserving feeling of fear has exercised a dominant influence. In the period of childhood, while independence is being acquired, the altruistic feeling of courage must take the place of the feeling of fear as a determining factor in leading to action. Many actions of childhood can be understood only by recognizing this fact. A boy likes to climb trees, the higher the better, and to walk over the roofs of houses where there is constant danger of falling. He likes to hang by his hands or his toes from a high beam or over a dangerous place. He is pleased to go swimming in a river where his parents have warned him that danger exists. Actions that are perfectly foolhardy, as seen by older persons, appear to have a great attraction for a boy.

Development of Courage.—The development of courage leads frequently to unpleasant actions also. A boy likes to stand on a railroad track as long as it is possible for him to do so before a passing train shall strike him. He will try how far he can go in his disobedience to his parents or teachers without coming to grief. It is some-

times a manifestation of courage much admired by his playmates, to disobey teacher or parent. Boys frequently tell their parents that they are exceedingly cautious. It is this development of the altruistic feeling of courage that furnishes the satisfaction derived from the playing of games in which the dare, or experiment with the will, is the principal feature.

Stories of Adventure.—The development of the feeling of courage is a necessary condition for the progress of cooperation. It is the development of this feeling that lends such a charm to the stories of adventure. The boy puts himself into the place of the hero of his story, and undergoes with him all the dangers that demand the manifestation of courage. The stories of Jules Verne, stories about robbers and pirates, the deeds of chivalry, the poems of Walter Scott, and the stories of the nature of Daredevil Dick and the Penny Dreadful so much reprobated by parents and teachers, all have a part in the development of courage and acquire their interest from the growth of this instinct so necessary to the child. Much as we may regret the choice of literature that the boy makes, it is not really so disastrous to him as it appears to older persons that it ought to be.

Cooperative Games.—The boy cannot become independent without the development of the feeling of courage. Courage is an altruistic feeling, necessary to the preservation of the community, and leads up to cooperation and social service. The two instincts, as contradictory as they seem in the abstract are inseparably bound up together, and one cannot exist in its most desirable form without the other. The development of the cooperative instinct is manifested in the plays of childhood, and is favored by them. The child needs the cooperation of another child, or other children to play

with. The games that delight are cooperative games. The most characteristic plays are competitive plays, and paradoxical as it may seem, fighting is one of them. Fighting is a cooperative play, and is a process of socialization. One boy cannot fight unless he has another boy to fight with him; and he cannot fight unless the other boy agrees to fight; so out of the most superlatively anti-social action, socialization grows.

Fighting.— Fighting is a cooperative, competitive play, but it is the extreme type of a great number of such games. There is no real occasion for the laudation of fighting among boys that has been indulged in by Stanley Hall and some of his followers. All the benefit that can possibly be derived from fighting is obtainable from other competitive games that are free from the atavistic implications of personal combat.

Infantile Plays Persist.—Many of the plays of infancy persist, but there are other plays especially characteristic of childhood that are not found in infancy. Among the characteristic games that differ especially from those of infancy may be reckoned marbles, racing, jumping, games of pursuit, and other games in which the element of attractiveness is the surpassing of one boy by another. They are especially competitive games, but it will be observed in all games characteristic of childhood, the competition is altogether of an individual character. The excellence is that of individual excellence. The individual undertakes to excel the other, or all the others. There is little thought of team play, or working for the success of the side, to the obscuring of individual effort, and there is little disposition to play partners.

Imitation of Team Play.—Sometimes little boys play football, or baseball, and in so doing closely simulate team play. But a careful examination will show that in-

stead of being team plays, such games when played by little boys in the ages of childhood are imitative plays, and more closely related by their motive to the plays of infancy, than by their form to the plays of adolescence. No team of little boys in the ages of childhood would ever develop or play a game of football or baseball, unless the game was played in their presence by boys who were older than the years of childhood.

Gangs.—The tendency toward cooperation, to courage and to independence leads to the formation of gangs and secret organizations, often of a predatory nature. Not only does this involve the idea of independence, leading to law breaking and disobedience, but it is also a manifestation of the instinct of cooperation. The formation of predatory gangs reaches its best development about the age of eleven to thirteen years, and when such gangs are continued much longer than this age, they must be regarded as manifestations of retarded development. Such gangs often participate in pilfering, stealing apples, chickens, melons, or in merely imaginative depredations, as in plays and dramatizations of piracy and robbery. Exemplifications of them are found in Tom Sawyer and in other pieces of literature. Such gangs frequently build or procure places of rendezvous and storage for their plunder in neglected houses, or in caves which sometimes they excavate for themselves.

Predatory Character.—Occasionally the proper character to make a boy an acceptable member of the gang will be found in his disposition to be bad, disobedient, courageous. Stunts that demand an exhibition of one or all of these qualities are sometimes imposed as conditions of initiation into the gang. Boys have been known suddenly to develop an unusual and unexpected streak of badness, and an investigation has shown it to be merely

an effort to become so bad that the members of the gang would admire and take him into membership.

Significance of Gangs.—When we understand the actions of children in this way, we shall see that membership in a predatory gang is not something that is to be altogether reprobated nor regarded as a manifestation of total depravity. It is in itself an indication of an instinct which is necessary to the full development of a useful citizen. When we realize the significance of actions of children which are of this character, we are ready to come into more sympathetic touch with them and to know better than it would be possible to do otherwise, how best to manage them, and to work with them in such a way as to enable them to pass through this stage which has so many annoying and reprehensible features.

Gang Code of Honor.—The development of the gregarious instinct, which is a necessary prerequisite to socialization and a condition of community life, as seen in associations of predatory gangs, often leads to the establishment of a code of honor peculiar to the organization, and which is not at all in accord with the ordinary ethical standards. Lying, stealing and other vices are overcome with reference to particular individuals, or the members of the organization. Lying is not to be indulged in when directed toward a member of the gang, but lies told a person who is not a member of the gang are not reprehensible. Stealing from a fellow member is iniquitous, but stealing from some person who is not a member is not only condoned, but may become a mark of distinction. This is a process of partial socialization which only needs extension to the whole of society to become an admirable characteristic. The charge of cowardice cannot be tolerated, while to inform on a com-

panion, or to "snitch" may be the worst crime in the decalogue of a predatory gang.

Code of Honor Among School Children.—It is a consideration of this kind that will enable us to understand the peculiar code of honor prevalent among children in school. Nothing can be more clearly demonstrated in ethics than that the person who knows of a crime and does not at least inform of the criminal, and testify of his knowledge to the authorities of the community, becomes a participant in the crime. But the standard of honor among children is such that they willingly become such participants. Although this code of honor is low, teachers must willingly or unwillingly accept it. The epithet of tattle-tale is an exhibition of the means by which public opinion exerts its force. That this standard of public opinion is only a stage in the socialization of children is seen by the fact that little children in the stage of infancy are all "tattle-tales," annoying to teachers, and needing to have their disposition to report the misdeeds of others curbed.

Secret Language.—A noticeable characteristic of childhood is the development of a secret language. Nearly every person in this period of childhood has invented a secret language of some kind. It may take the form of an invention of a secret alphabet, or the adoption of the alphabet of a foreign language that is known to few or no other person of his acquaintance. The hand signs of the deaf are frequently learned as a means of secret communication, and the learning is a manifestation of this disposition. Sometimes a language is formed by merely adding to the words of the vernacular an additional syllable, or by inventing new words.

Argument for Foreign Language Study.—Frequently the children desire to learn the words of a foreign lan-

guage that correspond to the English words. This is sometimes regarded as an indication of the development of an instinct to learn a foreign language, and the teachers are advised that the study of foreign languages should be undertaken in accord with the manifestations of such an instinct. Such a conclusion is unwarranted. It is rather a manifestation of a desire to form a secret language, and is an indication of partial socialization and oncoming independence. The child desires to have a power of communication that others do not have. It is related alike to the gaining of independence, the protest against accepted authority in language, and to the development of courage and the gaining of power. Instead of being a manifestation of a disposition to learn some language that is a means of expression by large numbers of people, the very essence of a secret language is that it shall be limited to a small number of people, the correlative of the gang. The boy or girl who knows a secret language, by that fact surpasses the others and excels them at least in one way.

Slang.—Related to this development of a secret language is the attractiveness of slang. Slang is the expression of revolt against constituted authority in language, and has a peculiar attraction for children, especially for those approaching the termination of the period of childhood. It is not altogether bad, but preserves the virility of language. It does not arise out of poverty of expression, as some persons have mistakenly supposed, but is rather an indication of fertility and resourcefulness in making many applications of a single expression. Thirty variations of the expression "Wouldn't that jar you?" have been noted.

Collecting.—Children early manifest a disposition to collect objects, which culminates about the age of ten or

eleven. They usually begin with a collection of spools or buttons or postage stamps, although almost any article may be employed as the basis of a collection. It is not usually the value of the article collected which makes it attractive, but the extent of the collection. The collecting tendency must be associated with the disposition to manifest power and the instinct to become independent. As wealth in a fully developed society is regarded as an indication of power and independence, so the collecting play of children may be considered as a manifestation of the instinct, which, when it takes wealth as its object, leads to the kind of independence and power which accumulated wealth is supposed to give. It arises out of the instinct to become independent, and is one of the processes by which that result is achieved.

Puzzles.—Puzzles have an attraction for children, and there seems to be a difference in the kinds of puzzles that are attractive at different ages. Simple guessing games are the first, and this is followed by riddles, mechanical puzzles, geometrical puzzles, and later by arithmetical puzzles. The puzzle disposition can scarcely be called an instinct, but it is associated with the development of intellectual power and the feeling of intellectual superiority. It is often of the nature of a competitive play, the powers of one child being pitted against the powers of the other who has proposed the puzzle, or against the puzzle itself. While it is far removed, it is related to the development of power, or will, or courage, and little to socialization.

Using the Puzzle Disposition.—It is this puzzle disposition, leading to competitive play that the teacher can successfully appeal to in teaching arithmetic. Arithmetical problems may be considered as puzzles, the mastery of which involves the application of principles whose

fixing is the purpose of the series of problems. The competitive disposition is employed, not necessarily against other pupils, but by each child against his previous record, or against the problem itself.

Differentiation of Boy and Girl.—In all these illustrations the boy has been referred to instead of the girl. What has been said about the boy applies with modifications to the girl, although the principles and development of the fundamental instincts is better exemplified in the boy than in the girl. In the period of childhood the boy progresses farther along the line of development than does the girl. He becomes farther removed from the primary condition of the infant, and approaches more nearly to the specialized capabilities of the functions of warfare, hunting, and struggle for wives that constitute such a large part of the mature life of the fully developed man. The development of the element of courage and independence is less well marked in girls than in boys, hence boys manifest the greater difference between the period of childhood and that of infancy. The eleven year old boy manifests the characteristics of the period of childhood in their most typical form.

SIDELIGHTS

The child develops naturally no strong convictions concerning the sins of untruth and stealing until after the age of puberty; children are often designated as natural liars.—*Marshall, Instinct and Reason, p. 173.*

Men have contracted the habit of enforcing the advantageous activities expressive of social instincts upon children long before they feel the inborn impulse which one day would lead to the spontaneous appearance of these activities.—*Marshall, Instinct and Reason, p. 174.*

The rise of an infancy period is necessitated by the demands of later life in creatures in which plasticity and intelligence take the place of fixity and instinct.—*Baldwin's Dictionary, Article Recapitulation, Volume II, p. 428.*

DEFINITIONS

Childhood.—The period from about the age of seven to twelve or fourteen.

Gregarious Instinct.—The feeling that impels animals to seek the company of their kind.

Cooperation.—Working together.

Cooperative Play.—That kind of play in which the participation of a companion of approximately equal ability is demanded.

Competitive Play.—That kind of cooperative play in which the game consists in an attempt to surpass the other player.

Courage.—The community preserving feeling, contrasted with fear, which leads one knowingly to run into situations that are dangerous.

CHAPTER XXXIII

The Psychology of Adolescence

Adolescence.—Adolescence is that period of a child's life included approximately between the years of fourteen and twenty-one, although for girls it begins about two years earlier and may be considered as complete two or three years sooner. It is the formative period immediately succeeding that of childhood, and is indicated not by years, but by certain well marked physical, physiological and psychical changes.

Physical Changes.—The beginning of the period of adolescence is marked in the first place by a period of rapid growth which exceeds in intensity and rapidity any other except that which occurs in the first year of infancy. Tables of growth show that the child in this period increases in height about three inches in each of three years. Tables of this kind are, however, always misleading, for in fact, in the life of any one child, the growth is never distributed over three years, but nearly all of it occurs in some one year. Nearly every boy grows in some one of the years from fourteen to sixteen four to six inches in height, while weight increases in almost the same ratio. In girls the maximum of growth is manifested by the largest number in the thirteenth year, and in boys the largest number manifest it in the fifteenth year.

Adolescent Growth.—Growth in height and weight is merely the sum of the growths of the different parts in the body which do not at all increase proportionately.

The growth in height is composed of the sum of the increases in vertical dimension of the skull, the vertebrae, the femur, tibia, and the arch of the foot. Every part of the body grows in its own proportion, and the measurement of height and weight does not indicate at all the whole story of growth.

The Heart.—One element in bodily growth is of so much importance that it is necessary to mention it specifically. In the year of adolescent growth the heart increases in capacity in the proportion of 160 to 225. Before the period of rapid adolescent growth, the relation of the capacity of the heart to that of the arteries is about 56 to 20. In the period of rapid adolescent growth, the ratio increases to 97 to 20, which will be recognized as a tremendous increase in the disproportion between the two organs. This increase in the different capacity of the two sets of blood carrying organs is the occasion for a very much heightened blood pressure, which is manifested in a tendency to nosebleed in many adolescent youths. It is without doubt associated with the rapid increase in growth in other parts of the body, and a sudden development of association fibers in the brain, together with the appearance of instincts that are new and characteristic of the adolescent youth.

Voice.—In the boy there is a noticeable change in the voice by which it attains a register an octave below that of the same person in the period of childhood. A similar change but much less pronounced occurs in the voice of the girl. In the boy, the beard begins to make its appearance, although this indication of oncoming manhood is slow and appears later than the change in voice or the rapid growth.

Biological Maturity.—But the greatest change in the adolescent and the most important difference between

the adolescent and the child is that the oncoming of adolescence is the establishment of biological maturity. It is the period that corresponds to the flowering time of plants, and like the adolescent, the flowering time is the period of most rapid growth. The century plant, at flowering time, sends up a stalk in a few weeks ten or twenty feet high; while in the twenty or more years preceding this time, no such amount of growth has been approximated.

Social Instinct.—It is this biological maturity which is the correlative of the development of one of the strongest and most imperative instincts in the human constitution. The adolescent differs from the child, psychologically, especially in the development of two great instincts, and the entire mental life of the individual is modified and determined by them. One of these instincts is the growth of the social nature. The growth of socialization has been accomplished in a partial degree in the child, and we have described this partial or individual socialization as cooperation. But in the adolescent, socialization is completed and the social development of the adolescent differs decidedly from the cooperative development of the child. In childhood cooperation appears in its most significant character as a form of competition. In the adolescent, socialization takes on the form of mutual aid for a definite end.

Team Plays.—A good example of the growth of the social instinct in adolescence is observed in the plays that interest adolescent children. In the child, the competitive plays are individual competitive plays. In the adolescent, while the individual competitive plays continue, the plays that are especially characteristic are team plays, in which, it is true, the element of competition enters very largely. The interest of the adolescent, how-

ever, is in the success or manifestation of superiority of his side, or his team, or his school. Here is the place and the time in which loyalty and patriotism are attained, even at the sacrifice of self. Self abnegation and even immolation is attained, and the selfish disposition is replaced by a truer altruism.

Football.—A typical example of team play is football, in which, in order to be a successful player, the individual must sink his own individuality in the work of the team. It is this feature that makes football as it is played in colleges, a game that merits the hearty support which it receives from the players, the student body, and the faculty. Some persons profess an inability to discriminate a game of football from a prize fight. The external appearance is not very different, but there is a great difference in the spirit of the two. A prize fight is a competitive individual play; a game of football is a competitive team play. A prize fighter is in the social stage of a child, and would never become a good football player. A football player is in the adolescent stage of social development, and is able to sink his individuality in the success of his team. A prize fighter, if he is a successful one, may be regarded as an example of retarded or permanently arrested development. His low grade of social development is inevitably accompanied by a low grade of moral development, and few prize fighters can justify any higher claim.

Moral Maturity.—This tendency to become social is one of the two instincts which distinguish the adolescent psychologically from the child. Since morality arises out of the community preserving feelings, and is expressed by the actions consequent upon them, the adolescent enters fully into the moral life of the community. Lying, stealing, cheating, gambling, all the specific moral delin-

quencies should have disappeared by the time the adolescent changes are completed. If they have not, the individual who manifests them must be regarded as an example of retarded development. In general, the courts hold that full moral responsibility begins at fourteen, although it is a recognition of instances in which the adolescent processes have not become fully established that leads many states to forbid the infliction of full punishment upon an offender before he has attained the age of sixteen.

Social Responsibility.—In general, too, compulsory education laws provide that the child shall not be compelled to attend school after having attained the age of fourteen, and this must be taken as an unconscious recognition of the fact that the person in whom the adolescent changes have become fully established has arrived at the age when he may cease to be regarded as lacking in responsibility. This is the age, too, at which in a primitive or savage state, the adolescent is inducted into full membership in the tribe, indicating a recognition of the fact that he has attained his social majority, and become completely socialized. He is ready to participate in the activities of the community and to conform to the demands of community life. His feelings have changed so that they are dominated by the community preserving instincts, and his actions are altruistic actions.

Persistence of Egoistic Feelings.—This must not be understood to imply that none of the self-preserving or egoistic feelings persist. Their demands are just as imperative as ever. It is as necessary that the individual shall be preserved as it is that the community shall continue. But the community preserving feelings are experienced at the same time, and occasionally in conflict with the self-preserving feelings.

Speculative Subjects.—As a consequence of the strong development of the community preserving feelings, we shall observe a decided change in the interests of adolescents, and a difference in the kind of reading that the adolescent is inclined to pursue. The development of new instincts has changed his outlook upon life, and he appears to be in a new world. The adolescent is very likely to be attracted by questions of a far-reaching and unanswerable nature. Philosophical speculations are likely to prove attractive and school subjects that are of a speculative kind are frequently preferred. Psychology and political economy, or perhaps better, descriptive astronomy, and the aspects of physics, chemistry, and zoology that are largely theoretical and speculative are likely to be favorites.

Increased Intellectuality.—The better organization of the brain centers leads to a greater ability to perceive relations and to do better thinking, especially when we couple this with the heightened blood pressure which leads to the generation of a greater amount of nervous energy. This is a condition in which we do not necessarily infer a decreased amount of feeling, while at the same time we may recognize the possibility of greater intellectual work being done.

Race Perpetuation.—The second great instinct whose development discriminates the adolescent from the child is that of race perpetuation. The race perpetuating feelings are those appropriate to family life, such as the love of a parent for a child, a husband for a wife, or a wife for a husband, either present or prospective.

Love Plays.—The change in disposition incident to the development of adolescent love and the race-perpetuating feelings is seen in the plays that are characteristic of adolescence. It is not meant that other plays are

suddenly displaced, but that the plays before unappreciated suddenly begin to have a great attraction for the person in the adolescent stage of growth.

Dancing.—The first great group of plays that may be mentioned are love plays, which are distinguished from other plays by the fact that the cooperation of a partner of the opposite sex is demanded. As example of such plays we may mention dancing. Dancing when performed by children, as it sometimes is, is a muscle play, but when engaged in by adolescents, although the muscle play and movement play features continue, is truly a love play. The association of a partner of the opposite sex is demanded, and it is by this feature that we may distinguish the adolescent dancing from the dancing of children. In adolescent dancing, the attractiveness of the play resides largely in the love play feature.

Kissing Games.—Here we may mention also the kissing games, sometimes imposed as penalties in the game of forfeits. Such are post office, measuring ribbon, walk the dismal swamp, and a hundred others. Even athletic games, such as tennis, and card games, take on the form of love plays when partners of opposite sex are engaged.

Childish Love.—It should be observed here that in childhood there is a close simulation of love play, and frequently a warm affection may spring up between children of opposite sexes. This childish love, however, does not arise from the race perpetuating feelings, and is associated rather with community preserving feelings. It is related to the cooperative instinct rather than the love instinct. It is scarcely different from the fidelity manifested between two boys who are chums, or two girls who are devoted to each other. It is often encouraged to simulate love play by the suggestive teasing of

older persons, and participates in the general features of an imitative play. It is scarcely more closely related to the love play or to the feelings upon which love plays are based than is the doll play to the maternity instinct.

Novel Reading.—Upon this instinct of adolescent love is based the entire group of imaginative plays which may be called the novel reading group, in which the chief interest is centered upon the love story. Novel reading is a play of the imagination, and is quite as characteristic of adolescence as the story of adventure is of childhood. When we recognize the magnitude of the interest that is indicated by the name novel reading, and see the thousands of books that are published every year in which the love story is the prominent feature, then we may be prepared to understand more fully the universality of the interest and the dominating power of the instinct that appears in full strength at the adolescent age. Every one of the "six best sellers" will be found in the list of novels, and the love story is the thing that makes it popular. Even the twenty best sellers will all of them be found to achieve their popularity from the force of this instinct which comes into full energy only at the oncoming of adolescence.

Theater-Going.—To this list of love plays we may add theater-going. Very few plays can succeed that do not tell a love story in its most intense form. The blood and thunder drama is so stigmatized by older persons, because it is one that appeals to the adventurous instincts of childhood, and is likely to be largely patronized by that class of persons who have developed slowly through the period of childhood, and retain psychological indications of their childish condition when from their age we should expect them to have passed beyond it.

Adolescent Manners, Dress, Speech.—Novels, or love

stories, are never popular with children below the adolescent age. The boy, at least, is very likely to express an exaggerated antipathy for anything so foolish as a love story, but this attitude is quickly changed by the adolescent influence. Equally noticeable will be the changes realized in the dress and manners of the adolescent youth. The boy or girl who has been careless and indifferent in his attire, speech and manners is likely to manifest a decided improvement, even if not an exaggerated fastidiousness in the attention he gives to the niceties of the toilet. Such differences are closely related to the development of the instinct of reproduction and courtship exemplified in abundance in birds and all the higher forms of animal life.

Importance of Race-Perpetuating Instinct.—From a consideration of the things mentioned above, we shall be prepared to understand the tremendous importance of the adolescent changes and the accompanying instincts in the life of the individual, as well as their overwhelming significance in the life of the race. The whole philosophy of human life grows out of the two great series of feelings, the self-preserving and the race-perpetuating. The community preserving, or moral, feelings seem to be an outgrowth of the self-preserving feelings, and while sometimes overshadowing them, are later and less fundamental. The race-perpetuating feelings dominate even the community preserving feelings, and conformity to the demands of community institutions always has a conflict with the race-perpetuating activities, and frequently is overcome by them.

School Discipline.—It will be readily understood that in the stage of adolescence we see the completion of the process of becoming independent, and the taking on of the functions of community life in its completeness. It

will also be understood that the methods of discipline in school must be very different from those which were employed with the greatest advantage in the preceding stages. The adolescent is a fully responsible being and must be guided in his actions by the impulses which spring up from within. He must be directed by his own judgment and when that judgment is wrong, he must suffer the natural consequences, even though those natural consequences be the disapprobation with all its uncomfortable effects, that the other members of the community visit upon him. Hence we shall find that the school discipline in grades which are composed of preadolescents, will be wholly inapplicable to those in whom the adolescent changes are completed.

Adolescent Religious Experience.—Another conclusion is deserving of our consideration. It is in the adolescent period that the greatest number of religious, as well as philosophical, conversions occur. Greater changes of opinion are likely to be found in this period than in any other. It is common to apply the term conversion to a particular religious experience, but it is equally applicable to any other great change which amounts to a reversal of previously held opinions, or to a fixing of those that have been held only tentatively before. The mental processes are likely to take on their final form, and after this period, only modifications, and not complete reversals, are likely to occur.

The missionary spirit is likely to become completely established in the period of adolescence, and the feeling of complete self-abnegation with a devotion of one's self to missionary work is likely to be determined in this transition period of storm and stress, although its working out may be much delayed beyond the termination of adolescence.

Adolescent Dependence.—Adolescence is the period of high school and college education. This is a period of dependence, in which the adolescent youth is not employed in earning his own living, nor participating completely in the activities of the community life around him. He is not initiated into full membership in the community, as he would be if he were living in the primitive condition of the savage tribe. A young man is not allowed to vote at fourteen or fifteen, but is restrained from voting until he is twenty-one.

Benefit of Prolonged Dependence.—It has been shown by John Fiske that the chief characteristic of man by means of which he is enabled to reach the head of the long line of animated creation, and retain his position there, is a consequence of the greatly prolonged period of infancy, by which the nervous system is kept in a state of plasticity, permitting the attainment of a much higher degree of complexity of organization than is possible to any other animal, or would be possible to man in any shortened time. The fact that in civilized society the period of adolescence, from the fourteenth to the twenty-first year is generally regarded as a proper period for school education, and that youth is not expected to enter completely into the social functions of the community, as is done in the primitive or savage life, shows that it is a lengthening of the period of dependence and a promise of continued plasticity. It contains a pledge of the attainment of a degree of human development that has not been possible in any previous age of the world's history. It is putting an additional story upon the structure of the human being, and is the most hopeful indication of increased human development that can be found in modern society.

SIDELIGHTS

More conversions occur in the last three years of this period (early adolescence) than in any other three years of life, while about two-thirds of all conversions take place between twelve and twenty.—*Kirkpatrick, Individual in the Making, p. 228.*

The religious instinct appears in the child almost coincidentally with the appearance of the sexual instincts.—*Marshall, Instinct and Reason, p. 487.*

Religious life and growth might almost be said to consist in gradually transforming theological into psychological ideas.—*Hall, Adolescence, Volume II, p. 325.*

DEFINITIONS

Adolescence.—The period of a child's life from about the age of twelve or fourteen to twenty-one.

Biological Maturity.—The stage of development at which the individual becomes capable of reproducing the species.

Gregarious, or Social, Instinct.—The instinct that leads individuals to live together in communities, or in a society.

Team Play.—Any kind of game in which the effort of an individual is directed toward winning for his team or side.

Race Perpetuating Feelings.—Those feelings which accompany actions that tend to perpetuate the species and benefit the young.

Love Play.—Any kind of play in which the cooperation of a partner of the opposite sex is demanded.